SPACE AND THE AIRLAND BATTLE

A thesis presented to the Faculty of the
U.S. Army Command and General Staff College
in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

JOHN S. PRALL, JR., MAJ, USA
B.S., United States Military Academy, West Point NY, 1977
M.S., The Massachusetts Institute of Technology, Cambridge MA, 1987

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Name of candidate: Major John S. Prall, Jr.

Title of thesis: Space and the AirLand Battle

Approved by:

Samuel R. Miles, Thesis Committee Chairman
Mr. Samuel R. Miles, BA

Donna S. MacTaggart, Member, Graduate Faculty
Major Donna S. MacTaggart, BS

Lowndes F. Stephens, Member, Consulting Faculty
Lieutenant Colonel Lowndes F. Stephens, Ph.D.

Accepted this 7th day of June 1991 by:

Philip J. Brookes, Director, Graduate Degree Programs
Philip J. Brookes, Ph.D.

The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement).

ABSTRACT

SPACE AND THE AIRLAND BATTLE by MAJ John S. Prall, Jr., USA, 220 pages.

This study investigates how well the potential of space technology is incorporated by the Army into its warfighting doctrine. The study examines the potential benefits of space systems for the military, focusing on Communications, Navigation, Reconnaissance and Surveillance, and Weather support. It evaluates which aspects of the warfighting doctrines, both AirLand Battle and its successor AirLand Battle Future, can be enhanced by the use of space systems. It describes the current Army space infrastructure and makes a determination as to its effectiveness in integrating space into the Army's day to day operations.

The Army already uses space technology to some extent in its operations. Examples cited from America's recent conflicts, particularly those from Operation DESERT STORM, indicate that the Army recognizes the utility of space assets and is endeavoring to find ways to effectively use them.

The study concludes that the Army should be a tactical and operational <u>user</u> of space services, not a strategic <u>operator</u> of space systems, but that it does not yet fully accept that situation. Consequently, Army space operations remain somewhat unfocused, with emphasis shifting between support of national strategic requirements and the needs of the Army's operational and tactical level AirLand Battle commanders.

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The future of the Army is not in space,
but in the mud.

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Military Review, 1986

The Army must have Army space systems
tailored to the AirLand Battle
commander's requirements.

Colonel Linas A. Roe
Military Review, 1986

For some forty years, the Army has been seeking to identify an appropriate role for itself in the nation's space program. Originally cast in a leading role, it soon faded into the background from whence it has only recently and hesitantly emerged. Extremely divergent opinions on the subject have been voiced over the years, often at the same time and in the same journal, as the two quotes above seem to indicate. Even the very manner in which the question asking about that appropriate space role for the Army is posed, ends up being a matter for dispute.

Should it be 'The Army in Space', or 'Space in the Army?' Unfortunately, a clear cut answer to either question has not yet emerged.

Historically, the Army was at the forefront of the nation s push into space and remained so until eased aside by other competing forces within America's emerging space program. Only recently has it again become interested in space activities, and only now is it examining at how to best utilize the potential benefits of space in support of Army forces around the world. It is discovering at the same time, though, that investments in space are a somewhat risky business, and a very expensive one at that. Risk and money are not something the Army can easily afford at the moment.

For better or worse, the Army leadership has embarked on a course which seeks to take advantage of space assets, hopeful of their promise but aware of their enormous costs. The problem which the Army now faces is to ensure that its doctrine adequately incorporates those promised benefits so that the costs are not wasted. Even now, doctrine is being devised which will determine how the Army operates in the year 2025. It is imperative that those writing that doctrine, and those who will be required to execute it in the future, fully understand how completely it relies on space assets.

This author will argue that the Army is tentatively headed in the right direction, but the steps which are being taken do not adequately address how absolutely essential space assets are going to be to the Army in the future. AirLand Battle itself is already relatively dependent on such assets for the success of its deep battle, yet the word 'space' does not appear once in FM 100-5, and space education of the officer corps, the 'users', is given short shrift in Army schools. The next two iterations of Army doctrine, AirLand Battle Future and Army 21, become admittedly even more space dependent; yet those who are developing those doctrines typically do not discuss space in their briefings and do not appear demonstrably concerned with the preparation of the officers who will execute the doctrine. Although the Army as an institution wants to be in space, it has not yet developed a focused way to do that successfully.

Purpose of the Thesis. This thesis will be an unclassified evaluation of how well and how completely the Army's AirLand Battle doctrine, both current and future, integrates the capabilities made available by the nation's space program. This will be done by determining the potential uses of space systems by the Army, and evaluating if the Army recognizes that potential. The dependence of AirLand Battle doctrine on space-based platforms will be determined, and an evaluation made of how fully the Army recognizes and plans for that dependency. The vulnerability of this doctrine to hostile space-based platforms will also be examined. The same determination will be made for the next planned iteration of Army warfighting doctrine, AirLand Battle Future. Both doctrines will be examined in light of current and projected changes in budget, technology and threat, and a determination made of whether the provisions for incorporating space assets into each version of the doctrine will remain adequate in the future or if they should be modified to accommodate a changing world.

Historical Background. The Army's association with space began with the capture by U.S. Seventh Army troops of the V-2 rocket team consisting of Wernher von Braun and 126 other German scientists and engineers at the close of World War II. Following this event, the Army was preeminent in the nation's space effort for nearly two decades. Dr. Von Braun and his team were captured in the spring of 1945 along with over 300 boxcars of V-2 rockets and spare parts. All of these were shipped following the close of the war to White Sands Proving Ground in New Mexico, where experiments were initiated by Dr. Von Braun for the Army's Ordnance Corps using the captured V-2s.[1] After transferring in 1949 to the larger and more modern research facilities of the Army's Ordnance Missile Laboratories in Huntsville, Alabama, at what was to later become known as the Redstone Missile Arsenal, Dr. Von Braun and his scientists worked on the development of the Redstone missile. This was to become the first successfully launched heavy ballistic missile following its lift-off in August 1953.[2]

A string of other 'firsts' followed. The development by the Army of the nation's first anti-ballistic missile, the Nike-Zeus, quickly followed in 1956. The nation's first satellite, Explorer I, was launched on 31 January 1958 by the Von Braun research team working for the Army Ballistic Missile Agency using an Army Jupiter-C missile. The world's first active communications satellite was built by Army researchers in 1958, and the first two Americans in space were launched aboard Army Mercury-Redstone missiles.[3] The Army, it seemed, was in the space business.

However, for a number of years there had been some conflict between the Army and the Air Force regarding each other's space role. The development by the Von Braun team of controllable, accurate long-range ballistic missiles threatened one of the newly created Air Force's primary reasons for existence, that of nuclear weapons delivery to strategic depth. Initial efforts by the Joint Chiefs of Staff in 1950 to resolve this conflict assigned the Air Force the responsibility for 'strategic' guided missiles, and the Army responsibility for 'tactical' guided missiles. However, range distinction between these two types of missiles was not specified and so remained a source of debate. Both services continued their separate research and development missile programs, the Air

Force working on the Atlas, and the Army on the Redstone.[4] Matters eventually came to a head in late 1956, at which time the Secretary of Defense defined the range limit between the two services' missile programs as 200 miles. The Army was given responsibility for the development and employment of the short-range 'tactical' missiles; the Air Force for the long-range 'strategic' missiles.

Stripped of its long-range ballistic missile role, the Army continued hoping for employment of its Redstone/Jupiter in a space role.[5] Complicating this option, though, was a new civilian competitor. The creation of the National Aeronautics and Space Administration (NASA) by the National Aeronautics and Space Act of 1958 separated the nation's military and civilian activities in space. NASA was granted research, development and management responsibilities for all civilian activities in space, and those activities were given priority support within the government. Consequently, most Army space systems, to include assets such as the Jet Propulsion Laboratory, the von Braun research team and many space mission responsibilities, were transferred to NASA by 1960. Further diminishing the Army's space role, a decision by the Secretary of Defense in 1961 gave the Air Force responsibility for all Department of Defense (DOD) space research and development.[6] With the exception of limited anti-ballistic missile research, the Army was now virtually out of the space business.

Army space activities for the next two decades consisted primarily of responsibility for research and development of ballistic missile defenses and, to a lesser degree, of satellite communication facilities. Work on tactical missiles continued at Huntsville, with the development of the Pershing system being most noteworthy. By and large, though, the Army's space role had "declined from being the lead service in space operations in the late 1950s to that of the customer of the services provided by space systems."[7]

Faced with competing demands on its limited resources, such as conventional force restructuring following the draw-downs of the 1950s, the effort put into the Vietnam conflict, and the Defense Department's designation of the Air Force as its space proponent, Army interest in space operations remained at low ebb until the mid-1970s when some people in the Army began to recognize that a great deal of the technology being utilized in space had benefits for the Army's field commanders as well. About the same time, national policy-makers were reevaluating the Outer Space Treaty of 1967, which guarantees the neutrality of space bodies and prohibits the orbiting of nuclear weapons, and the ABM Treaty of 1972, which prohibits the development, testing, and deployment of ABM systems which are partially or completely composed of space-based components. Further impetus to the Army's emergent interest in space was provided by President Reagan's proposal for the Strategic Defense Initiative (SDI) during a televised address on 23 March 1983, in which he called for an ambitious research program designed to eliminate the threat to the nation from ballistic missiles. A significant part of this new initiative would be the Army's on-going research and development efforts in anti-ballistic missile technology. With this new responsibility as its motivation, the leaders of the armed forces, and particularly those in the Army, began to seriously consider the potential of space from a military viewpoint. Space began to be touted as the new "high ground" which should be militarily secured as any other piece of terrain.

As a result of this newly recognized significance of space, and because of the increasing number of space systems now being employed by the military, serious efforts were initiated in the mid 1980s to centralize the military's space efforts. These initiatives led to the creation of the Air Force Space Command (AFSPACECOM) in September 1982, shortly followed by the Navy's

(NAVSPACECOM) in 1983. U.S. Space Command (USSPACECOM), a functional unified command headquartered at Peterson AFB in Colorado which has responsibility for all of the military's space operations, was created in 1985. It incorporated the existing AFSPACECOM, also headquartered in Colorado Springs, and NAVSPACECOM, headquartered in Dahlgren, Virginia, as two of its components. Army participation in this command initially consisted of an organization called the Army Space Agency, activated in Colorado Springs in 1986.[8] Eventually, after much analysis and considerable soul-searching, the Army Space Command (ARSPACE) was created from this agency and became a component command of USSPACECOM in 1988.

After neglecting it for many years, the Army has apparently become interested once again in space. The question now is whether it recognizes the potential benefits which can be derived from space operations and whether it will work to integrate those benefits effectively into its overall warfighting doctrine, the AirLand Battle, particularly through the coming lean fiscal years as other important demands compete once again for its attention and limited resources. In any event, it does seem that the Army is back in the space business to stay.

Significance of the Study. The major importance of this thesis is twofold: first, to demonstrate the degree to which Army doctrine, both current and future, is dependent on space; and second, to indicate which elements of the Army space program are actively aiding the success of that doctrine, and identify those which are not.

As the nation enters the 1990s, the U.S. Armed Forces are preparing to experience a significant reduction in their numbers and budget. Because the Cold War is now behind us, the perceivable threat to the United States has diminished so greatly that Congress and the American people are no longer willing to support a standing two million man armed force. However, despite the 'reduced' threat from the Soviet Union and the Warsaw Pact, the U.S. still has any number of potential enemies throughout the world against whom the Armed Forces must defend, as the Gulf War has so recently made evident. Thus, the anticipated reduction in force is to be done without any concurrent reduction in responsibility.

Of the nation's armed services it is the Army, more than any of the other branches of service, that apparently will feel the greatest impact of these reductions. While the Navy and Air Force have significant, and hence not easily reduceable, strategic deterrent missions, and the Marine Corps can claim to be the nation's force of choice for rapid 'forced entry' missions, the Army by and large is designed to forestall a heavy, Soviet threat in Europe. Consequently, it is the Army which can be most easily and acceptably cut, and hence it is Army programs which will be significantly reduced in scope, or eliminated entirely, to help bring the defense budget in line during the coming decade. Those programs that survive will have to be able to justify their existence in terms of their importance to the success of Army doctrine over the next several decades. Those programs which can show that they are essential to success will remain vibrant; those which cannot will fade quickly into oblivion.

At the moment, it is not readily apparent to all members of the Army how much the Army institutionally has come to depend on space for the success of its operations. Students at the Command and General Staff College at Fort Leavenworth, the Army's future leaders who will be responsible for the execution of future doctrine, question what return the Army gets from space and whether it is all worth the effort and expense. Articles in Military Review boldly state that "the future of the Army is not in space, but in the mud." Even such 'routine' things as command and control, intelligence preparation of the battlefield, and weather forecasting are enabled and significantly enhanced by space-based platforms, yet this assistance is generally not recognized or acknowledged. This dependence of the Army on space will likely become even greater in the future as the Army doctrinally shifts from the linear battlefield defined by AirLand Battle doctrine to the non-linear battlefield of AirLand Battle Future and Army 21. To ensure that the Army remains capable of executing the lofty doctrinal goals it has set for itself, a clear link between the Army's space program and the success of the AirLand Battle doctrines must be demonstrated to the officers and soldiers who are responsible for executing those doctrines. If that link is not established, quickly and definitely, the Army's space agencies will prove easy budget targets.

Calls are already being made to scale back the Army's participation in space as a budget saver. Some changes in organization have already been implemented, such as the dissolution of the Army Space Institute at Fort Leavenworth. The Army's anti-satellite program is receiving long, hard looks in Congress. The long-term effects of these and other changes must be thoughtfully considered so that short-term savings aren't achieved at the expense of the Army's future operational capabilities.

The Strategic Defense Initiative, already a prominent Defense Department R&D priority, may receive even more attention given the success of the Patriot anti-missile system in Operation DESERT STORM and President Bush's support for it in his 1991 State of the Union address. Although SDI is obviously not specifically an Army program, a good deal of that effort will have an impact on the way the Army conducts its operations as new applications are discovered for the technology developed for SDI. The capabilities of kinetic energy weapons such as the electromagnetic rail gun, directed energy weapons such as lasers, and the National Aerospace Plane are only now being unveiled for thoughtful scrutiny. Army applications for these new space weapon systems must be identified as early as possible so that they can be linked proactively to necessary changes in Army doctrine, organization, and fiscal priorities. If such proactive thought is not made now, the Army may not get a second chance in the future.

Assumptions. In preparing this thesis, only the minimum number of necessary assumptions have been made. These deal specifically with the availability and consistency of specific information. Those assumptions are:

- sufficient budgetary information is available for analysis to identify fiscal trends and draw conclusions about future budgets

- information about the Army's current utilization of space-based technology which is found in unclassified sources is sufficient for accurate analysis

- the United States government, the U.S. Air Force, and the U.S. Navy all have valid requirements to justify their participation in space operations; no additional justification for their space programs is required

- future Army warfighting doctrine, in the form of AirLand Battle Future, is sufficiently developed to permit accurate evaluation of its dependence on space operations

Definition of Terms. In writing this thesis, certain terms and concepts have been defined and are used throughout in a specific manner. These definitions are contained in Appendix B.

Limitations and Delimitations. The scope of this thesis has been intentionally restricted in order to present a reasonably digestible bite of information which will not overwhelm the reader and give him indigestion. The thesis deliberately examines only certain aspects of the Army space program, and declines to examine others, as follows:

1). The analysis is limited to the 'subjective' evaluation of how effectively current Army doctrine is being understood and implemented; this thesis does not include any surveys of individuals to determine their knowledge of the potential of space for the Army. Rather, data has been gathered from current Army space centers on utilization of space assets by ground commands and interpreted to indicate understanding of potential.

2). The study considers solely information on the nation's space program as it relates to Army doctrine; efforts have not been made to evaluate the relationship of that information to the space programs of the Navy or Air Force. As stated, the validity of the nation's and DOD's participation in space is assumed and not reviewed. That participation, and the 'doctrinal thought' behind it, is mentioned only briefly to give the reader a general understanding of it, but it has not been discussed at any length.

3). In-depth analysis has not been conducted on foreign space programs. The capabilities and limitations of the Soviet, European and other national space programs are compared with that of the United States, but no effort has been made to determine the direction of their research efforts, or their current or future budget priorities.

4). As the purpose of the thesis is not to evaluate Army warfighting doctrine, but to determine how well it incorporates the potential afforded by space assets, no changes to AirLand Battle doctrine are considered.

5). Since the thesis is unclassified, the author has relied entirely on information found in unclassified sources. No attempt whatsoever has been made to confirm or deny the validity of any of that information through classified sources. Additionally, the summary presented in Chapter 3 of the information obtained from those unclassified sources is kept deliberately general due to the sensitive nature of the subject.

Methods and Procedures A TRADOC problem solving model provides an analytical framework for the organization of this thesis. The model itself, as highlighted by former TRADOC Commander General Maxwell R. Thurman, consists of nine steps, as follow:

1. Identification of the Problem
2. Threat Analysis
3. Friendly Capabilities Analysis
4. Technology Assessment
5. Conceptual Alternatives
6. Operational & Organizational Plans
7. Analysis
8. Decision
9. Implementation[9]

The analysis in this thesis follows this methodology through Step 7; a Decision and its Implementation are obviously beyond its scope.

The Identification of the Problem, Step 1 of the methodology, is as expressed throughout this chapter. The Army's leadership has decided that the Army institutionally should be involved in space, yet it is not clear whether the ultimate intent of that decision has reached down to influence our current warfighting doctrine and the development of our future doctrine. In an age of reduced budgets and limited resources, it is imperative that that decision be linked definitively to doctrine.

Steps 2 through 6 provide the background information on which a conclusion may be drawn. This information is gathered by a thorough review of the extant literature dealing with space and Army doctrine. The goals for this Review of the Literature are discussed in the succeeding paragraphs here, and the highlights of the review are presented in Chapter 2 of this thesis. A determination of friendly and hostile space capabilities and an assessment of the technological potential of space, following Steps 2 through 4 of the methodology, are presented in Chapter 3. A discussion of the principles and operating systems of Army warfighting doctrine, both present and future, and the organizations which exist to implement them, following Steps 5 and 6 of the methodology, are presented in Chapters 4 and 5, respectively. Chapters 3, 4 and 5 thus provide the specific information on which conclusions may be drawn.

The ultimate goal of the Review of the Literature is to establish a base of knowledge from which further analysis may proceed. Naturally, this base must include information on both space capabilities and Army warfighting doctrine. Ideally, these answers come from sources both within and without the military-industrial community. In completing this literature review, efforts have been made to determine the validity of the information collected and the qualifications of the authors who provided it.

The literature review provides basic information about the civil, commercial, and military organizations which currently comprise the U.S. space program, their organizational structures, and the goals and responsibilities of each element of those organizations. A comparison with other comparable foreign space efforts, notably those of the Soviet Union and the European Community, then becomes possible. The review further provides information about the infrastructure and components of the U.S. space program, particularly the types of satellites which are currently in use, and some information about what innovations and new methods of utilization are forthcoming in the foreseeable future. Application of this current technology by the Army can then be reviewed, and developmental programs examined. The review also provides information about the "threat", describing organizations, systems, and technologies which are or may become potentially hostile to the U.S. space effort.

Looking at the Army itself, the review provides basic information about the present and future versions of the Army's warfighting doctrine, the fundamental principles on which the doctrine is based, and the systems and organizations which will be used to translate those principles into actual operations. This literature review of doctrinal sources focuses particular attention on the uses of space assets in executing AirLand Battle doctrine.

The completed Review of the Literature permits an analysis to be made of the extent to which Army doctrine is effectively incorporating the potential of space. This analysis, Step 7 of the methodology, is presented in Chapter 6 of this thesis in the form of conclusions and recommendations with which the reader could proceed to a Decision if that were deemed necessary.

The conclusions presented in Chapter 6 are intended to indicate how effectively current space technology is being utilized by the Army in AirLand Battle doctrine. Specifically, conclusions are drawn regarding the actions being made to fully integrate the potential of space technology into future U.S. Army warfighting doctrine. The author identifies the organizations responsible for integrating space technology into Army doctrine and for educating the officer corps about its employment, and assesses whether they are effectively accomplishing these tasks. Finally, the author examines how budget reductions may impact on the continued development of the Army space program, and how the effects of reduced budgets may be minimized.

Chapter 6 concludes with recommendations for organizational realignments and shifts in priorities, initiatives which will enable the Army to have a coherent, integrated space program well into the future.

NOTES

[1]John R. Wood, "The Army and Space: Historical Perspectives on Future Prospects," (MMAS thesis, U.S. Army Command and General Staff College, 1986), 24.

[2]Ibid.

[3]Pat Gagan, "The Army Space Command," Military Review 68 (March 1988): 45.

[4]Wood, 32.

[5]Ibid., 35.

[6]Ibid., 38-39.

[7]Jan V. Harvey and Alwyn H. King, "Space: The Army's New High Ground," Military Review 65 (July 1985): 39.

[8]John L. Piotrowski, "Meeting National Security Needs in the Fourth Dimension," Defense 87 (November/December 1987): 44.

[9]Maxwell R. Thurman, "The Army's Long-Term Outlook," an address presented to the Electronic Industries Association at Alexandria VA on 12 April 1989, from Selected Works of the Sixth Commander, United States Army Training and Doctrine Command, (U.S. Army Training and Doctrine Command, Ft Monroe VA, 1989), 142.

CHAPTER 2

A REVIEW OF THE LITERATURE

Knowledge is Power.
Hobbes, in Leviathan

All I know is what I read in the papers.
Will Rogers

The purpose of this Review of the Literature is to highlight those sources which I found useful in researching this thesis, and to indicate the general areas in which I looked for information. It is divided into two parts. These roughly correspond to the subject content of Chapter 3 and Chapters 4 and 5, respectively. The first details the books, periodical literature, government documents and other unpublished material which relate to space and U.S. space systems. The second covers the same groupings as they relate to the Army's warfighting doctrine and to its space doctrine and organizations.

SPACE ACTIVITIES

A great deal of information is available on the military uses of space. Articles have been published regularly in well-known periodicals, numerous books have been written on specific subjects, and several government documents detailing policies and options have appeared. Additionally, Congressional records afford much insight and information regarding the development and purpose of the United States' national space policy, and particularly its associated budgets. When conducting this research, I have looked exclusively at periodicals which have been published within the last five years. Anything much older than that invariably refers to obsolete technology, or to claims restated in more recently published contributions. I have, however, looked at books published before that time because the more in-depth analyses they present retain their value for a longer period of time. I have tried to be wary about relying on technical data in older books, concentrating instead on using older sources for their discussions of less time-sensitive concepts. When I have had to refer to technical data in this thesis, I have turned instead to current periodicals and government publications.

Although there are a significant number of books on the military uses of space, not all of them are germane to this thesis. For example, very little of the literature on the Strategic Defense Initiative (SDI) bears on the question of how well space technology is integrated into AirLand Battle doctrine, although it does provide useful background information by which to discuss the nation's space program as a whole. More relevant are books about the capabilities and limitations of specific types of space hardware, e.g. satellites and launch systems; with the capabilities and limitations of the Soviet and other foreign space programs; and with evaluations of U.S. space policy.

The periodical literature is more varied and relevant than the books. Journal topics can be generally categorized in three areas: U.S. systems, Soviet and foreign space capabilities, and U.S. policy. Articles in periodicals present a broader view of the world's space activities than do books or government publications. Naturally, they also provide information which is the most current of any set of sources.

Government documents appear to be the most relevant of all sources for determining the link between the potential of space and the military. They have the added benefit of covering an extremely wide variety of subjects, ranging from the deliberations found in the reports of Congressional committees, to policy statements made by the President and the Defense Department, to field manuals published by the Armed Forces. Associated with government publications are a handful of monographs which have been written over the past five years by serving officers about the Army's role in space operations. These are particularly useful as they track the development of thought following the Army's re-entry into space in the early 1930s through the creation of Army Space Command.

U.S. Capabilities. Some of the better books on U.S. satellite capabilities include Deep Black by William E. Burrows, a professor of journalism and director of the Science and Environmental Reporting Program at New York University; America's Secret Eyes in Space by Jeffrey T. Richelson, an analyst with the National Security Archives; Military Space Forces by John M. Collins, a senior specialist in national defense at the Library of Congress; Battle for Space by

Curtis Peebles, a noted author on high technology and a fellow in the British Interplanetary Society; and A Guide to Military Space Programs by C. Richard Whelan, an aerospace author and analyst. Burrows and Richelson both discuss the U.S. reconnaissance and surveillance satellite network in some depth, tracing its development from the days of the U-2 to the present family of intelligence gathering satellites. Whelan provides a good overall reference to U.S. space operations, discussing at some length national and individual armed service space policies, military satellite programs, uses of the space shuttle, and SDI. Both Collins and Peebles provide detailed discussions of U.S. and Soviet satellite capabilities. Peebles additionally describes ASAT programs and indicates how relevant portions of space law apply to them, and provides basic background information about present world-wide space installations and their functions. Collectively, these books have helped me to acquire a broad base of knowledge by which to understand the complexities of the modern space age.

Among the many articles which specifically relate satellite capabilities to military use are "NAVSTAR on the U.S. Army Battlefield" in Signal; "Space Systems in Tactical Battle Management" in Defense Science; and "Space Pays Off for the Field Army" in Army. Each of these discusses some aspect of the military's space system and shows its relation to Army operations. There have also appeared a handful of articles in various periodicals which relate the potential of space systems to the Army of the future. Examples of these articles are "Space Operations Tomorrow: Emphasizing the Tactical" in Defense 88; "Space-Based C3I is Critical to Future Contingency Army" in Army; and "LIGHTSAT: All Systems Are Go" and "Military Satellites: The Next Generation" in Defense Electronics. Articles found in Defense Electronics and Signal seem to deal most thoroughly with this area, while those found in Aviation Week & Space Technology are typically the most up to date.

Soviet & Foreign Capabilities. Several of the same books detailed above also discuss the Soviet space program. Military Space Forces by John M. Collins, and Battle for Space by Curtis Peebles are prime examples. Another which specifically discusses the Soviets is Soviet Military Strategy in Space by Nicholas L. Johnson, an advisory scientist for Teledyne Brown Engineering, a major U.S. aerospace contractor. In it, Johnson describes Soviet intentions and capabilities in the space arena, relating those capabilities directly to tactics on the ground. He also provides examples of Soviet employment of their space assets during the Falklands Conflict, during the Iran-Iraq War, and in Afghanistan.

Articles discussing the Soviets' space activities are found in a wide variety of journals. Some examples include "Soviet Military Space Programs" and "Soviet Space Doctrine for Warfighting" in Signal; "Soviet Military Space Programs" in International Defense Review; and "U.S. and Soviet Military Space Programs: A Critical Juncture" in Officer. As with articles discussing U.S. capabilities, each of these discusses some aspect of the military's space system and shows its relation to military operations.

Government publications provide a great deal of information about Soviet capabilities, although admittedly what is presented seems fairly heavily one-sided. Two such items are a book entitled The Soviet Space Challenge, written with a preface by then Defense Secretary Caspar Weinberger, and the annual DOD publication "Soviet Military Power." Each presents in some detail, and with lots of graphs and pictures, a vivid description of Soviet space doctrine and programs, and the capabilities of the satellite networks and space support systems which are used to execute their doctrine.

Generally speaking, the space capabiiites of nations other than the U.S. and Soviet Union are covered only in periodicals, not in books or government publications. Undoubtedly, this is because the Soviets have been viewed as the single hostile space threat to the U.S. space program for the past thirty years. Most of the articles describing the space activities of other nations highlight their use of communications and earth surveillance and monitoring satellites for purely commercial purposes, although it is easy to extend those capabilities to military applications. Some examples of those articles are "Europe Takes Its Place in Space" in Aviation Week & Space Technology; "French Charting European Course for Military Use of Space" in The Armed Forces Journal; "Proliferating Satellites Drive U.S. ASAT Need" in Signal; and "Commercial Imagery Comes Down to Earth" in Defense Electronics.

U.S. Space Policy & Doctrine. Two books which look at U.S. space policies are American Military Space Policy by Colin S. Gray, the president of the National Institute for Public Policy; and On Space Warfare: A Space Power Doctrine by David E. Lupton, a retired Air Force lieutenant colonel. Gray lists the reasons which compel the U.S. to be in space, describes current U.S. space policy, and points out several logical problems with that policy. Lupton presents a more theoretical discussion of what a viable space doctrine should include, describes what the composition of a space force designed for that doctrine should be, and then looks at current U.S. doctrine for comparison.

Some articles in journals which specifically discuss U.S. space policies and their relation to the military include "The Army in Space: New High Ground or

Hot-Air Balloon" in Military Review; "DOD's Space Policy" in Defense 88; "Space Warfare: The Need for Doctrine" in National Defense; and "The Army's Stake in Emerging Space Technologies" in Parameters. A regular contributor to several of these journals is General John L. Piotrowski, who recently gave up command of U.S. Space Command. Each of his articles discusses some aspect of USSPACECOM's operations, providing interesting insights into the present direction of U.S. policy.

As might be expected, government publications provide the greatest insight into the make-up of U.S. space policy. National security statements, issued in 1990 by the President and Secretary of Defense which outline the nation's intentions in space, are available for reference. A National Space Policy statement, issued by the President in 1988, indicates the direction in which the nation's space program is to head over the next several decades. Congressional reports, and testimony by government officials before Congressional committees, highlight much of those same topics and provide particular information about the government's space budget through about FY95.

In order to implement the nation's space policy, the armed services have issued several documents which specifically discuss their doctrine for space operations. The principal documents dealing with space operations are: by the Army - FM 100-18, "Space Support for Army Operations" (1990); and by the Air Force - AFM 1-6 "Military Space Doctrine" (1982). There are additionally several classified documents which deal more specifically with how the Army's space concept is to be translated into reality. Principally, these are the "Army Space Initiatives Study" (1985); the "Army Draft Space Architecture" (1988); and the "Army Space Master Plan" (1987). Because of their security classification, however, much of the information to be found in these documents is beyond the scope of this thesis.

A number of studies by military officers have been conducted over the past decade about the military's role in space. A 1985 National Security Affairs monograph The Emerging Role of the US Army in Space by Colonel Arthur J. Downey reviewed the Army's historic involvement with the space program and detailed the military aspects of that program. This document was written prior to the creation of USSPACECOM, prior to the creation of Army Space Command, and prior to the hiatus caused by the explosion of the Shuttle Challenger. A Command and General Staff College MMAS thesis entitled "The Army in Space: An Assessment of Today for Tomorrow" was written in 1990 by Captain Daniel R. Kirby. In it Captain Kirby goes through an analysis of the effectiveness of the Army Space Institute at Fort Leavenworth, concluding that it is at best treading water and appears headed for extinction, an insight that now seems to be fairly prophetic. He touches briefly on the integration of present Army space operations and AirLand Battle, but does not dwell on the point. A second MMAS thesis, "The Army and Space: Historical Perspectives on Future Prospects," submitted by Major John R. Wood in 1986, reviews the first Army experience in space in the 1950s in order to find applicable lessons which may help Army leaders as they reenter space in the 1980s. He provides a description of the Army's early space and missile programs and the issues which faced the Army as the Space Age began. Both the monograph by Colonel Downey and the theses by Captain Kirby and Major Wood provide a good deal of background information for this thesis, but they have not covered the same topics which are discussed here.

ARMY WARFIGHTING DOCTRINE

Naturally, the vast majority of my information about the Army's warfighting doctrines has come from Army publications and sources. Some insights may be found in periodicals, although these are invariably written by military officers in military journals. Despite this, indeed because of it, I feel confident that what I have collected accurately represents current thinking about how the Army intends to fight its wars.

In conducting this research into Army warfighting doctrine, I generally have again attempted to refer to only the most recently published information. However, when researching AirLand Battle doctrine I examined some articles which are more than ten years old. For this doctrine only I felt it necessary to review the arguments which were voiced when the doctrine was evolving, and so did not restrict myself solely to current articles.

AirLand Battle. The Army's current warfighting doctrine is outlined most prominently in FM 100-5, Operations. I additionally found insights on the doctrine in some military journals, notably Military Review, in which senior Army officers contribute their views on particular facets of the doctrine. Particularly useful were articles written in the early 1980s when AirLand Battle was being developed. Some of the authors writing at that time, such as then TRADOC Commander General Donn Starry, explain in some detail the arguments voiced then which eventually evolved into AirLand Battle as we know it today. One booklet which I found to be particularly useful was published by the Army War College in the early 1980s. Entitled simply AirLand Battle Doctrine, it was intended to be a means of making the officer corps at large more aware of the subtleties involved in the doctrine. It discusses all aspects of AirLand Battle, including sections on the doctrinal aspects of war in general and AirLand Battle in particular, to include the deep battle, the intelligence preparation of the battlefield, and the implications of the doctrine on combat service support. It is the only book I found which purports to directly describe what AirLand Battle doctrine actually is. I was also able to refer in my writing to briefing outlines which Generals Maxwell R. Thurman and John W. Foss, both TRADOC commanders, used to describe AirLand Battle doctrine to a variety of audiences. These documents, which include both narrative and viewgraph slides, present a most interesting and fairly detailed picture of how the Army's top doctrine developers view the Army's current warfighting doctrine.

AirLand Battle Future. Information about AirLand Battle Future, the Army's evolving doctrine which is intended to be implemented following the turn of the century, is naturally less well documented than that of the current AirLand Battle doctrine. Most of the information which I was able to obtain came from documents written by Generals Thurman and Foss, in which they again were describing the Army's future doctrine to a wide variety of audiences. Some of these documents were in the form of briefing outlines, much as those which I used when looking at AirLand Battle, while others were articles written for or interviews given to certain military journals. Military journals such as Army and Military Review have published a number of articles on the subject. Indeed, over half of the February 1991 issue of Military Review was devoted to discussions of AirLand Battle Future. Additional information was obtained from other sources at Fort Leavenworth. Particularly useful was a document entitled the "AirLand Battle Future Umbrella Concept" which lays out in fairly specific terms the concepts, limitations and impacts of AirLand Battle Future as it is currently conceived.

CHAPTER 3

THE POTENTIAL OF SPACE

> Space isn't just a place where tactical high ground is assumed and defended and used - it is a technological arena that is currently providing the genesis of new tactical devices and systems that the Army can ignore only at its peril.
>
> Elwyn Harris
> The Rand Corporation, 1988

> Space will be . . . a potential battlefield for the same reasons that the deep ocean and the air became battlefields.
>
> Colin S. Gray
> National Defense, 1988

The Space Age has captured the imaginations of millions of people worldwide, and has provided the world with previously unimaginable technological achievements. These achievments have done much to revolutionize the life styles of people everywhere, but nowhere more so than in the United States. In the course of a single generation, we have gone from radios working with vacuum tubes, to digital and laser signals transmitted by satellites. We have gone from forecasting the weather with Almanacs, to receiving daily long-range forecasts on the Nightly News. In the same time, military forces have gone from propeller driven airplanes to jets and intercontinental ballistic missiles, and from bullets and high explosives to lasers and particle beams. The state of the art of warfare has 'advanced' right along with the rest, so much so that, in the words of Colonel Paul A. Robblee Jr. writing in Parameters in 1988, "war in space itself is a distinct possibility in the 21st Century."[1]

This chapter examines the organizations and technology which the Space Age has created, particularly those which have military potential, and discusses some of the ways in which that potential is currently being used by military forces around the world. It presents the capabilities of those space systems currently in use, and those of systems which are expected to become operational during the next decade.

U.S. SPACE ORGANIZATIONS

The National Space Policy, issued in November 1989, stipulates that "United States space activities are conducted by three separate and distinct sectors: two strongly interacting governmental sectors (Civil and National Security) and a separate, non-governmental Commercial Sector."[2] The National Aeronautics and Space Administration (NASA) is the government's proponent agency for the Civil Sector; the Department of Defense (DOD) is the proponent for the National Security Sector; and NASA, DOD and the Departments of Commerce (DOC) and Transportation (DOT) are cooperatively responsible for the encouragement of the growth of private sector commercial use of space. Together, these three sectors control a combined space budget which for FY90 was $31 billion; by comparison, the Soviet Union is estimated to spend about $45 billion annually on space.[3] Ideally, all three sectors will function together to avoid duplication of effort and to support U.S. space goals.

NASA was created by the National Aeronautics and Space Act of 1958. As the proponent agency for the Civil Sector, its responsibilities are for advancing space science, exploration, and appropriate applications of space technology through the conduct of activities for research, technology, development and related operations. It accomplishes these responsibilities at numerous locations across the country in conjunction with the National Oceanic and Atmospheric Administration (NOAA), and with the Department of Transportation.[4] NASA is also responsible for the manned space program, and the Space Transportation System (STS), better known as the Shuttle, which is currently the nation's only manned access to space. NASA operates with an average budget of about $8 billion per fiscal year, representing about 40% of the total U.S. space budget. In real terms this has been rising steadily since about FY75, and has increased sharply since FY88. In FY90 the budget was $12.3 billion; a 24% increase, to $15.2 billion, was proposed for FY91, although only $13.9 billion was eventually approved. Estimates made in 1990 in the U.S. Budget forecasted an additional 37% increase to $21 billion for NASA by 1995.[5]

In addition to NASA, both NOAA and DOC are involved in the Civil Space Sector. NOAA supervises the Landsat program, consisting of land remote-sensing satellite operations, and manages civilian weather satellites for DOC.[6]

Since it is by definition non-governmental, the Commercial Sector is not controlled by a specific government agency. However, the National Space Policy directs NASA, DOD, DOC, and DOT to work together to promote the commercial use of space. The National Space Council, created in 1989, acts as a focus for commercial space issues. DOT regulates commercial launch vehicles, and DOC acts as an advocate for other private sector space activities.[7] The U.S. hopes to foster private sector involvement in space by making available space-related hardware and facilities, and encouraging commercial space ventures.[8]

DOD is responsible for the military aspects of the nation's space policy. As such, in accordance with the National Space Policy, it is to conduct space operations which contribute to national security objectives by:

1). deterring, or if necessary, defending against enemy attack
2). assuring that forces of hostile nations cannot prevent our own use of space
3). negating, if necessary, hostile space systems
4). enhancing operations of United States and Allied forces[9]

To execute these space operations, DOD has determined it must provide adequate space support in the form of redundant launch systems and facilities, and of survivable, autonomous satellites. It must ensure U.S. access to space, and provide the ability to deny access to our adversaries. It must develop, maintain, and operate space systems which support the requirements of the nation's land, sea, and air forces, and be prepared to deploy additional space systems as situations warrant.[10] As will be described throughout this chapter, not all of this is within DOD's capabilities at present, but it is the goal toward which its space activities are directed. To accomplish all this, DOD operated a space budget of $18.1 billion in FY90, which was a 18% increase from FY89.[11]

There is some interface between the space programs of the three sectors. The STS is used by both NASA and DOD for civil and military missions, respectively. The Civil Sector is directed to encourage the use of unmanned, expendable launch vehicles by the Commercial Sector by contracting for those services when necessary. DOT is the proponent for the development of commercial launch capabilities, in consultation with the Civil and National Security Sectors.[12]

Several DOD organizations implement national security space policy. As a result of the newly recognized significance of space, and because of the increasing number of space systems being employed by the military, efforts were initiated in the mid 1980s to centralize the military's space efforts. These initiatives led to the creation of the Air Force Space Command (AFSPACECOM) on 1 September 1982, shortly followed by the Navy's (NAVSPACECOM) on 1 October 1983. Ultimately, these organizations and the Army's space organization were placed under the operational command of the United States Space Command, which was established in 1985.

U.S. Space Command (USSPACECOM), a functional unified command headquartered at Peterson AFB in Colorado which has responsibility for all of the military's space operations, was activated on 23 September 1985. It incorporated the existing AFSPACECOM, headquartered in Colorado Springs, and NAVSPACECOM, headquartered in Dahlgren, Virginia, as two of its components. Army participation in this command initially consisted of an organization called the Army Space Agency, activated in Colorado Springs in 1986.[13] This agency became the Army Space Command (ARSPACE) in 1988. As a unified command, USSPACECOM provides a centralized control over the nation's military space assets and acts as a focus for all DOD space efforts. USSPACECOM's mission includes both space operations and aerospace defense responsibilities. As part of space operations, it must provide space support to ensure space control, and to enhance the warfighting abilities of the forces of the other unified and specified commands. As part of aerospace defense, it provides warning of aerospace attack, and controls the planning and development of the nation's Ballistic

Missile Defense (BMD).[14] The staff of U.S. Space Command currently consists of members of each of the Armed Services; typically, approximately 50 percent are drawn from the Air Force, 30 percent from the Navy and Marines, and 20 percent from the Army.[15]

AFSPACECOM was established as an Air Force major command to consolidate all Air Force space activities. It is organized into three space wings and several supporting organizations. The 1st Space Wing, headquartered at Peterson AFB in Colorado Springs, is responsible for operating 20 missile warning, satellite surveillance and communication stations located worldwide.[16] This network provides missile warning, space surveillance, intelligence gathering and communications for DOD from sites spread from the continental U.S. to Greenland to Germany to South Korea.[17] The 2nd Space Wing, headquartered at Falcon AFB, also in Colorado Springs, provides command and control functions for several DOD satellite systems, notably those satellites which comprise the Global Positioning System and the Defense Meteorological Satellite Program. It also is responsible for the daily operation of the Air Force Satellite Control Network, with tracking and monitoring stations located worldwide.[18] The 3rd Space Support Wing, located at Peterson AFB, provides base operating support to Peterson AFB itself, in additional to non-operational support to the 1st and 2nd Wings and their geographically separated subelements.[19] Recently, AFSPACECOM assumed control of DOD's launch facilities throughout the United States. AFSPACECOM has approximately 8500 military and civilian personnel.[20] It controls an average annual budget of nearly $15 billion, which represents roughly 80% of DOD's entire space appropriation.[21]

The Naval Space Command is headquartered at Dahlgren, Virginia. It is responsible for providing direct space systems support to the Fleet worldwide and to protect the Fleet from Soviet satellite capabilities. As such, it makes the Navy the nation's principal tactical user of space sensors. To accomplish its missions, NAVSPACECOM operates satellite control facilities at locations worldwide.[22] One of its principal responsibilites is the operation of a chain of dedicated space tracking sensors situated across the United States. It also operates the Transit navigation satellite system and the Fleet Satellite Communications (FLTSATCOM) system, which serve Navy position and communication requirements.[23]

Army Space Command was activated at Peterson AFB on 7 April 1988 as the Army's newest command. It is responsible for Army participation for the operational planning in national and defense space programs. It also is responsible for operating and maintaining the Defense Satellite Communications System (DSCS) Operations Centers, and the operation of the space surveillance and space object identification operations at Kwajalein Atoll.[24] ARSPACE will be discussed in greater detail in Chapter 5.

Funding of DOD's space operations has fluctuated over the years. From the plentiful times of the early 1980s, the Defense Department's budget has been in decline in real terms since at least 1989. Expressed in terms of a percentage of Gross National Product (GNP), DOD's budget claimed 5.8% in FY89, 5.1% in FY90, and is projected to decrease to 4% in FY95. Actual budget authority, expressed in dollars, was $290.8 billion for FY89, $291.4 billion for FY90, and $295.1 billion for FY91. Although the total dollar amount is obviously increasing annually, when these numbers are adjusted for inflation the actual amounts decline in real terms. As an example, the decrease in spending authority in real terms between FY90 and FY91 is 2.6%. Along with the total budget, the DOD Research and Development (R&D) budget has declined in real terms from $40.6 billion in FY89, to $38.3 billion in FY 90, to $38.0 billion in FY91.[25] The space-oriented portion of this R&D budget stands at $18 billion for FY90.[26] By comparison, NASA's total FY91 budget is $13.88 billion.[27]

The Strategic Defense Initiative (SDI) is the single biggest activity within the DOD R&D budget. Run by the Strategic Defense Initiative Organization (SDIO) it enjoyed dramatic budget increases during the mid 1980s, despite disputes about its effectiveness. However, Congress has shown itself to be increasingly reluctant to appropriate the funds which the President has requested for the program. The following figures compare the SDI budget's requested versus appropriated funds, in billions of dollars, since the mid 1980s:[28]

TABLE 1. - Strategic Defense Initiative Budget

	Requested	Appropriated	% Appropriated
FY85	1.8	1.4	78%
FY86	3.8	2.75	72%
FY87	4.8	3.3	69%
FY88	5.2	3.6	69%
FY89	4.5	3.6	80%
FY90	4.6	3.57	78%
FY91	4.6	2.9	63%

Source: Thomas Moore, "SDI Prospects for the 1990s," Defense Electronics 22 (March 1990): 42.

Note: All budget requests and appropriations expressed in billions of dollars

As with all portions of the defense budget, the Army's space budget has shrunk from previous fiscal years and can be expected to shrink even more in the future. FY85 was the last fiscal year in which the Army experienced any real budget growth. Since growing 11.7% then, primarily on the strength of the initial SDI funding, the budget has continually shrunk.[29] Projections out to FY95 obviously become increasingly dismal. One bright spot is the Army's Research, Development, Test and Evaluation (RDTE) budget. If it alone is examined in terms of dollars, or as a percentage of the total Army budget, some growth is seen. Table 2 illustrates these budget trends.

TABLE 2. - Army Budget Trends

	Army Budget	Total Army Real Growth	RDTE Budget	Percent of Total Army
FY88	*	-2.1%	4.6	*
FY89	79.0	-1.0%	5.15	6.5%
FY90	77.7	-4.2%	5.42	7.0%
FY91	76.1	-5.6%	6.03	7.9%

Source: The Fiscal Year 1991 Army Budget, a fact sheet published by the Association of the United States Army, (Arlington VA: AUSA, 1990): 14, I-1.

Note: All budget figures expressed in billions of dollars; * indicates unavailable information.

Thus, although the Army's budget as a whole is shrinking, RDTE, which is considered a future-oriented activity, is steadily growing. By comparison, the RDTE budgets for the Air Force and Navy for FY91 are $13.3 billion and $9.1 billion, respectively.[30] With regard to all space activities, the biggest space-related budget user controlled by the Army is the Anti-Satellite (ASAT) program. This activity has shown dramatic fiscal increases. In FY90, for example, it was funded for $73.9 million; that figure has jumped to $207.8 million for FY91.[31]

SPACE CAPABILITIES OF THE UNITED STATES

Despite budget constraints, the space organizations of the United States have put together an impressive infrastructure which gives the U.S. enormous capabilities. The remainder of this chapter describes those capabilities, particularly as they relate to the military, and compares them to the capabilities of other nations around the world.

U.S. SATELLITE SYSTEMS

The functions of all military satellites fall generally into five categories: Communications; Navigation; Reconnaissance, Surveillance and Target Acquisition; Weather and Earth Sensing; and Geodesy and Mapping. The United States employs all of these types, as does the Soviet Union. Although other nations employ military satellites, they typically are involved only with Communications and Earth Sensing. In the United States, the military has become heavily dependent on space-based platforms over the past twenty-five years.

This section is a discussion of U.S. satellites systems, their capabilities and limitations, and some of the ways they are currently used by our armed forces.

Communications

Communications satellites are considered by many to be the single most important military function of space systems today. Today, about ninety percent of all U.S. overseas military communications transit through space.[32] The United States employs several different types of military communications satellites.

All fit into a world-wide system of military satellite communications, known as MILSATCOM, which uses a series of geostationary satellites operating across the frequency spectrum. Organizationally, MILSATCOM is composed of the Defense Satellite Communications System (DSCS), the Navy's Fleet Satellite Communications (FLTSATCOM) system and Leased Satellite (LEASAT) system, and the Air Force Satellite Communications (AFSAT) system. Access to MILSATCOM is shared by the National Command Authority (NCA), the Commanders-in-Chief (CINC) of the U.S. command structure, the Joint Chiefs of Staff (JCS), and other DOD users.[33] This access is allocated by the JCS in accordance with strategic requirements; typically, the Army is a low-priority user with requirements for forces at theater level and below going unsatisfied.[34]

In general, all military communications satellites can be grouped into three categories, depending on the frequency range in which they are designed to operate. Ultrahigh frequency (UHF) satellites operate in the 225-400 MHz range. These types typically are relatively inexpensive, but have low capacity levels and are highly susceptible to jamming. Super high frequency (SHF) satellites are more durable than their UHF brothers and can usually handle more traffic, but are more complex and hence more costly. Extremely high frequency (EHF) satellites are the top of the line, very survivable and highly resistant to jamming, with good capacity, but the most expensive.[35] Most older communications satellites are UHF systems, with newer and more capable designs operating in the SHF range. EHF systems are the wave of the future.

FLTSATCOM, LEASAT and AFSAT all operate in the ultrahigh frequency (UHF) range. These systems are used by the Navy and Air Force, respectively. FLTSATCOM is the UHF linkage between all Navy aircraft, ships and submarines with their ground stations, Strategic Air Command (SAC) headquarters and the

NCA. Five FLTSATCOM satellites ring the earth to form the constellation.[36] The final FLTSATCOM satellite was launched in 1987; LEASAT is intended to be its successor until a follow-on can be developed.

Satellites of the LEASAT system are owned by Hughes Communications Services, Inc., but are leased by the Navy.[37] Essentially a commercial adjunct to FLTSAT, it is a peacetime system which is not nuclear hardened and has no anti-jam capability.[38] Satellites of both the FLTSATCOM and LEASAT systems occupy high inclination orbits which provide worldwide communications coverage.[39] The ultimate FLTSATCOM successor, known as the UHF Follow-On (UFO), will probably have a 39 channel communications capacity, and be equipped to handle one SHF uplink in addition to its UHF capability.[40]

AFSAT provides high-priority Command and Control (C^2) for U.S. strategic forces.[41] Unlike the other systems, AFSAT does not consist of a specific satellite constellation; rather, it is a network of communications transponders which 'hitchhike' on other satellites. For example, 'host' systems for AFSAT packages include FLTSATs, Air Force Satellite Data System (SDS) satellites, and DSCS satellites.[42] Using SDS satellites which are located in high-inclination 'Molniya' orbits, the system enables trans-polar, two-way realtime command, control and communications.[43]

Although the Army does not own any MILSATCOM space assets, it assumed responsibility for the DSCS Operations Centers in 1990. The prime function of DSCS is to provide high capacity secure voice and data links for the U.S. Worldwide Military Command and Control System, or WWMCCS, which links the NCA with the combatant CINCs.[44] It also supports AUTOVON and AUTODIN traffic, in addition to transmissions between the CINCs and their component commands, and from early warning sites to strategic operations centers. Two types of satellites, the DSCS-II and DSCS-III, are currently in operation in the system; a third is in development. The standard configuration for the DSCS-II or DSCS-III is four operational satellites orbiting in geosynchronous earth orbit (GEO) with two on-orbit spares. Currently, four DSCS-IIIs and three DSCS-IIs are in orbit.[45] Both models operate in the superhigh frequency (SHF) spectrum. The older DSCS-II, first launched in 1971, is a spin-stabilized satellite built by TRW which has a design life of five years. Its successor, the DSCS-III, first launched in 1982, is three-axis stabilized, with 61 receiving antennas, and 19 transmitters. It is capable of 1300 simultaneous voice transmissions. Designed and built by GE, it has an operational life of ten years. The follow-on model, DSCS-IIIC, will feature enhanced anti-jam capabilities and electromagnetic pulse (EMP) hardening, and will extend the frequency range of the satellite into the extremely high frequency spectrum.[46]

Army access to the DSCS satellites is made via the Ground Mobile Forces Satellite Communications (GMFSC) terminals, which are typically fielded at corps level and above.[47] One such terminal is the Multichannel Initial System (MCIS) for the theater area which uses both DSCS-II and DSCS-III channels in the superhigh region. Army use of these DSCS SHF satellites played a large role during Operation Just Cause in Panama, along with use of the Navy's FLTSATCOM UHF satellites.[48] However, a growing congestion in both the ultrahigh and superhigh frequency regions is forcing the military to expand into the extremely high region.[49] This is the prime reason for the shift in DSCS-IIIC capability. It is also the driving force behind the development of a number of other systems which should come into use in the 1990s.

The satellite system which is to replace the DSCS series, effect the utilization of the EHF range, and support U.S. military communications into the

21st Century is the Military Strategic/Tactical and Relay satellite, or MILSTAR. Developed by Lockheed Missiles & Space Company, it is designed for survivability, with EMP hardening against nuclear blast and lasers, and anti-jam capabilities due to narrower transmission beams and frequency hopping.[50] The complete MILSTAR constellation will consist of 8 satellites placed in orbit by the Titan IV booster.[51] Four of these eight will be placed at GEO to cover the equatorial regions, while the other four will be in high-inclination orbits to cover the polar regions. Two of the eight will serve as on-orbit spares.[52] They will use a 44 GHz data uplink, and a 20 GHz downlink for the system's communications. MILSTAR will also retain a UHF capability, in addition to its primary EHF operating regime, to remain compatible with existing systems.[53] Additionally, it will feature a 60 GHz crosslinks capability, meaning that it will be able to reroute communications transmissions to alternate ground stations or through other MILSTARs. This extra capability is extremely significant, because it will make MILSTAR a switchboard, not merely a relay as other current communications satellites are.[54] This crosslinks capability, which is virtually impervious to ground interception, will enable MILSTAR to provide 24 hour near real-time communications connectivity without the added burden of a centralized control network.[55]

DOD planners consider MILSTAR to be the centerpiece of the military communications network for the next two decades. Billed as "the world's most survivable satellite,"[56] 10 MILSTAR satellites were originally planned at a system cost of approximately $10.5 billion.[57] As described above, eight of these would be placed in orbit. The other two would be kept in reserve on earth. Original plans were for the MILSTAR constellation to be deployed in two blocks. Block I would consist of three developmental satellites; Block II production models would incorporate several unspecified systems upgrades.[58] As of 1990, however, the program was experiencing cost overruns in addition to budget cut-backs, and only three of the planned ten satellites had been funded.[59] Additionally, the Navy has decided that even if the full MILSTAR constellation is eventually deployed, it will only be capable of handling 41% of validated Naval communications requirements. This shortfall, and MILSTAR's high cost, played a large part in the Navy's decision to develop the UHF Follow-On system.[60]

The Army is developing three new communications systems to use in conjunction with MILSTAR when it becomes operational, ideally in the mid 1990s. To replace the SHF dependent MCIS, the Multichannel Objective System (MCOS) is being developed. It will use Mobile Subscriber Equipment (MSE) to support the communications network at the corps/division/brigade level. MSE, which is essentially a mobile area telephone network, has voice, data and fax capabilities. MCOS additionally is being designed to connect with the Army's tactical satellite (TACSAT) terminals, a number of which are under development. One prototype, the Single Channel Man-Portable terminal (SCAMP) developed at MIT's Lincoln Labs in 1985, weighs only 67 pounds and can process digital message traffic. It is felt that such EHF ground terminals will ultimately weigh approximately 40 pounds and be capable of handling voice transmissions as well. The SCAMP radio can be broken down into two suitcase size units and should permit commmunications between non-adjacent units and in undeveloped theaters.[61] At the theater level, the Single-Channel Objective Tactical Terminal (SCOTT), being developed by Magnavox, is to provide a C^2 link on the battlefield; SCOTT will be limited in its abilities, however, and is not intended for use by tactical cummanders.[62] Other ground terminals being developed for use by ground forces will be described in Chapter 5. The Navy and Air Force are also developing

MILSTAR terminals for their use. The design of all three services' terminals is such that each will be capable of communicating with the other, thus avoiding past communicative sins.[63]

Naturally, the military is not the only user of communications satellites. NASA operates a number of satellite systems, such as the Tracking and Data Relay Satellite system (TDRSS), which relays communications between spacecraft and ground control. NASA is presently developing a new system, known as the Advanced Communications Technology Satellite (ACTS). This satellite is intended to demonstrate the viability of several new technologies for communications satellites in general. The tentative launch date for ACTS is currently set for 1992.[64]

A number of international communications networks also exist. Probably most noteworthy is the International Telecommunication Satellite Organization (INTELSAT), initiated by the United States in 1964, which currently has 118 member nations. It operates an international satellite system which has 13 satellites on station in geosynchronous orbit which together provide 2000 communications links between more than 170 countries around the world.[65]

Navigation

In addition to the traditional requirement to know where you are, the ability to determine precise position on the ground has become increasingly important to the Army as it fields new fire support systems which depend on such information. The satellite system which the U.S. military first fielded was called Transit. Declared operational in 1964 and run by the Navy, it provided two-dimensional position data in latitude and longitude, but required fairly complex analysis equipment and did not provide continuous coverage. Transit is still widely used in the United States by the civil sector.[66]

The successor to Transit, which will be capable of providing 24 hour, all weather, worldwide three-dimensional data is called the Navigation System Timing and Ranging, or NAVSTAR. It is designed to provide time, velocity and position data to both civil and defense agencies. It uses the Global Positioning System (GPS) to transmit precise position data to anyone with an appropriate receiver, with an accuracy to within ten meters. The system is composed of three segments: a control segment consisting of a master control station and several monitoring stations which is responsible for positioning the satellites, monitoring them and transmitting data to them; the satellites themselves; and the user equipment, or receivers.[67] A secondary capability for NAVSTAR is nuclear burst detection. Each satellite carries an optical sensor called the Integrated Operational Nuclear Detonation Detection System (IONDS). As the NAVSTAR constellation becomes complete, it will assume responsibility for nuclear burst detection from the Air Force's Vela satellites, which were orbited during the 1960s.[68] The Air Force is the DOD executive agency for the NAVSTAR/GPS program.

The master control station is the Consolidated Space Operations Center (CSOC), run by the 2nd Space Wing of AFSPACECOM at Falcon AFB, Colorado. Five monitoring stations and three ground antennas, controlled by 1st Space Wing, complete the control segment. The monitoring stations, at CSOC, Ascension Island, Hawaii, Kwajalein Atoll and Diego Garcia, track the satellites, receive data from them and relay it to the master control station. The ground antennas, at Diego Garcia, Ascension Island and Kwajalein, transmit commands to the satellites from the master control station.[69]

The NAVSTAR/GPS constellation of satellites is intended to have 18 operational satellites and three on-orbit spares in six orbital planes when it becomes fully operational by 1992. Each of the satellites will be placed in a 10,900 mile, semi-synchronous orbit with an orbital inclination of 55°.[70] When fully deployed, the satellites will be positioned such that a minimum of four are observable from any point on earth 24 hours a day. Built by Rockwell International, each satellite costs approximately $65 million and has a design operational life of ten years.[71] Each is equipped with an internal atomic clock which is accurate to within one second every 36,000 years.[72] The first ten satellites placed in orbit, beginning in 1978 and continuing until 1983, are typically referred to as the 'Block 1' spacecraft. These satellites, weighing more than half a ton and launched on Atlas boosters, were designed to last for only five years. Only six of these ten currently remain operational.[73] The second generation model, the 'Block 2,' weighs close to a ton and is launched on a Delta II booster. The first of this series was launched on 14 February 1989; nine other Block 2s have been launched as of December 1990, and plans are to continue launching them at a rate of one every two months until the entire constellation is complete.[74] At the end of 1990, there were a total of 13 operational satellites.[75]

In order to provide accurate data, a minimum of three satellites must be observable by the user for a two-dimensional position fix, while a minimum of four satellites is necessary to obtain a fix in three dimensions.[76] For successful three-dimensional operation, four visible satellites are required because GPS essentially calculates position in four dimensions, three for location and one for time, and four sets of data are necessary to accomplish these calculations. The receiver on the ground establishes radio contact with the four satellites, then determines the precise range to each one by measuring the time it takes for a radio signal to travel from the satellite to the user.[77] The position of the satellites in their orbits is transmitted to the receiver in a so-called NAV-message, which includes the ephemeris (present and future locations) of the satellites being tracked.[78] With the NAV-message from each of the four satellites, and the range determination between each of them and the user, the user's location on earth may then be calculated by solving a set of simultaneous equations, essentially by triangulation.

The NAV-message itself can be sent using a broad spectrum technique, which makes the signals highly resistant to jamming, over two different L band frequencies. One of the signals, called the Coarse/Acquisition code (C/A code), is carried on the L_1 frequency band at 1575.42 MHz. It is available for reception by anyone with a receiver. The second signal, called the Precise code (P code), is carried on both the L_1 and the L_2 frequency band (1227.60 MHz) and can be received only by authorized users such as DOD and select NATO nations.[79] The C/A code signal provides position accuracy of about 100 meters, which is similar to that of other navigation/positioning systems, such as <u>Transit</u> or the civilian <u>Loran</u> system, which have been in use since the 1960s. In theory the C/A code can yield accuracies of 15 meters; the U.S. government artificially degrades the signal so that it will be less useful for military purposes.[80] The P code, on the other hand, provides an accuracy which is estimated to be 20 to 100 times better than any other system yet devised.[81]

The user segment of the system comes in either manpack or vehicular mounted forms. It receives signals from the GPS satellites and converts them into positon, velocity and time on earth. This information can then be read on the receiver's display readout. The position data can indicate the receiver's location in either the Military Grid Reference System, the Universal Transverse Mercator/Universal Polar Stereographic system, or in standard longitude and latitude. Latest versions of the manpack weigh about 10 pounds and have a volume of 200 cubic inches; both figures are expected to be halved by the end of 1991.[82] The unit can operate for up to 48 hours intermittently on standard Army lithium batteries.[83] Nearly 25,000 GPS receivers are expected to be placed on Army vehicles, on Air Force and Navy aircraft, and on warships.[84]

GPS information is intended to be available on the P code to all DOD users. Procurement of the receiver units which make up the user segment is now underway, the first having been received by the Air Force in September 1987.[85] Ultimately one will be used by all Army aircraft, all Army vehicles, and by ground troops down to at least platoon level. The Signal Corps is the Army proponent for this acquisition, and is working to integrate its capabilities into the Enhanced Position Location and Reporting System (EPLRS). This system, which will be discussed later in Chapter 5, is intended to continually monitor the locations of all units equipped with a receiver, so that they can be plotted and transmitted to other friendly units.[86]

Currently, approximately 2000 receivers have been produced by the Collins Government Avionics Division of Rockwell International; however, a new contractor, SCI System Inc., was selected in 1990 to produce 6046 additional receivers over the next five years at a cost of $175 million.[87] A quick math check shows that the cost of one of these receivers, produced to military specifications, will run about $30,000.

Other commercial firms have also gotten into the market, however, and are producing receivers for only a fraction of that cost. To supplement the military receivers, DOD issued a requirement for the purchase of a smaller

Non-Developmental Item, built to commercial standards rather than military specifications, called the Small Lightweight GPS Receiver, or SLGR (pronounced "slugger"). To date nearly 2000 of these have been procured from Trimble Navigation.[88] These 'Trimpacks', as they are called, are about the size of a pair of binoculars, and cost about $4000. They can operate on battery power for 21 hours. Since the Iraqi invasion of Kuwait in August 1990, an additional 6000 SLGRs have been ordered.[89] Another firm, Magellan Systems Corporation, advertises in Army a hand-held GPS receiver, the GPS NAV 1000M, capable of receiving the C/A signal and providing position data accurate to within 25 meters. It is powered by six AA alkaline batteries, weighs less than two pounds and sells for $3500. Aviation Week and Space Technology reported in its 17 December 1990 issue that the Army has contracted with Magellan to purchase 500 of the NAV 1000M units for troops of the First Infantry Division in Saudi Arabia. Magellan also produces a slightly less accurate version aimed primarily at civilian maritime users costing only $3000.[90] Some of these units have proven themselves to be so popular and so beneficial that soldiers' mothers have bought units and shipped them to Saudi Arabia.[91] Additionally, Rockwell/Collins is offering a receiver the size of a pack of cigarettes which weighs a half pound and has P code capability.[92]

GPS has already seen considerable tactical use. The Navy borrowed GPS receivers from AFSPACECOM and installed them on the minesweepers which were involved in clearing the Persian Gulf of mines during the so-called 'Tanker War.' The receivers allowed the ships to determine their position to within sixteen meters, which made it possible for them to sweep their assigned sectors on precisely determined paths with no overlaps. The Navy liked the system so much it never returned the receivers.[93] During Operation JUST CAUSE in Panama in

December 1989, Army soldiers carried GPS receivers in their rucksacks; aircrews using GPS receivers could find airdrop and pickup points without difficulty.[94] An Air Force crew flying a GPS-equipped RC-135 in the annual SAC bombing and navigation competition did so well that SAC may not let any other GPS-equipped aircraft compete until everyone is so equipped.[95] GPS is being incorporated into all new Air Force F-16s.[96] Additionally, GPS receivers are found in the Standoff Land Attack Missile (SLAM), essentially an improved Tomahawk cruise missile. According to its manufacturer, GPS typically gives SLAM an accuracy that is within 15 meters.[97] GPS has proved itself to be nearly indispensable for aiding navigation in the desert during Operation DESERT STORM.

In addition to its military applications, GPS is being tested as an autoland system for commercial aircraft. Over a two month period in late 1990, the Space Systems Group of Honeywell completed 36 successful landings using position data obtained from GPS, instead of a standard microwave autoland system. It is thought that such a system will become more practical than either the standard instrument landing system or the microwave system because GPS will ultimately be accessible to aircraft practically anywhere in the world.[98]

Many people have expressed concern about the possibility of military exploitation of GPS signals by hostile nations. One example often cited is the effect which GPS data could have on medium and long-range ballistic missile accuracy. During the so-called 'War of the Cities' in the Iran-Iraq conflict, Scud missiles fired by Iraq often fell more than a mile from their intended target. GPS enhanced missile navigational aids could bring this miss distance down to merely one hundred meters. Questions also exist about the long-term security of the P code, given the vast sums of money intelligence services spend on code-breaking worldwide.[99]

All in all, the use of GPS for navigation and position locating is the single largest use of space technology by the Army to date.

Reconnaissance, Surveillance & Target Acquisition

The United States has deployed a sophisticated constellation of Reconnaissance, Surveillance and Target Acquistion (RSTA) satellites over the years. Not much information is released by DOD about the nation's RSTA assets; tight secrecy naturally surrounds these systems. Currently, as reported by William Burrows in Deep Black, the U.S. RSTA assets provide strategic intelligence for the national intelligence community.[100] These are indeed 'deep black' programs, and so will not be discussed in any great detail here. This discussion will cover only the most general and non-sensitive highlights of the programs.

The surveillance satellites of the Defense Support Program (DSP) are currently the bulwark of the U.S. strategic early warning surveillance effort. Run by the Air Force, DSP's purpose is to provide early warning of ballistic missile attack to the National Command Authority, separate and distinct from any similar functions which may be incorporated into SDI. The DSP satellites, developed by TRW at a cost of $180 million each, utilize 12 foot Schmidt infrared telescopes to provide stereo data to USSPACECOM's Missile Warning Center.[101] A constellation of three DSP satellites, each operating at GEO and carrying the Nuclear Detection (NUDETS) device, provide coverage of ground missile launches from the Soviet Union.[102] As widely reported in various media sources, such as Aviation Week and Space Technology, USA Today, and The Army Times, they have also been used to detect Scud missile launches from Iraq during its war with Iran, and more recently during the attacks against Israel and Saudi Arabia during the Gulf War.[103]

Reconnaissance satellites fall generally into two categories: electro-optical imagers and radar imagers; and signals collectors. The most recent versions of the reconnaissance satellites downlink their images directly to earth stations; this represents a major step forward in U.S. reconnaissance abilities. Prior to their advent, imaging satellites had operational lives of only a few weeks, and could only provide their pictures to earth by ejecting them in capsules which would then have to be recovered. The electro-optical imaging satellites reportedly use imaging technology similar to that which is used by the Hubble Space Telescope.[104] Just as with any modern satellites, the newest versions permit substitution of 'black boxes' by shuttle astronauts in case of failure, are capable of on-orbit refueling, and can be maneuvered in their orbits to alter their ground track and shift from high to low altitudes.[105]

One probem with the operational and tactical utilization of the information provided by the nation's RSTA assets is that it has typically in the past remained in the hands of the strategic users who operate the systems. Due to security requirements, it often has taken days for such key imagery to trickle down to the field. As an example, during the planning for the U.S. attack on Libya in 1986, photos obtained by satellite were hand-carried from analysts in America to the fleet in the Mediterranean, rather than send them directly from the satellite to analysts in the fleet. Instead of the data being fed directly to the field commander, the trip instead took three days.[106] Some tactical commanders have indicated that they fear in a major crisis this type of intelligence bottleneck will occur on a grand scale as satellite imagery and the ability to access satellite networks is commandeered by users at the national level.[107] Reportedly, this problem did not occur during the conduct of Operation DESERT STORM, where analysis was conducted in-theater.[108]

Another drawback of the increasingly sophisticated U.S. RSTA capability is that a relatively few satellites can perform a great number of functions. This is a tribute to the satellites' sophistication and abilities which, when coupled with the increasingly high cost for each satellite, leads to the policy of relying on a small number of satellites in space. Consequently, the total U.S. ability to monitor hostile portions of the globe is concentrated in only a handful of satellites. The loss of a single one, to hostile action or simple malfunction, thus represents a severe loss in U.S. reconnaissance capability. It has been noted that this situation "creates the potential for a space-based Pearl Harbor."[109]

Some suggestions have surfaced for resolving these problems of satellite vulnerability and intelligence bottlenecks. One is the development of lightweight satellites, or LIGHTSATs, which would be under the control of the theater commander and could be launched within 72 hours of his order to do so to supplement or replace the existing satellite constellations. LIGHTSATs will be discussed in more detail later in this chapter. A second solution is known as distributed surveillance, in which an entire constellation of low-cost satellites is put in orbit which would be dedicated to tactical, vis a vis strategic, intelligence. Such satellites would provide the combatant CINCs with 1 meter resolution surveillance capability, and would serve as a redundant system to the national RSTA constellations.[110]

The Army has investigated how it can employ RSTA assets to its tactical advantage in a study entitled the Tactical Exploitation of the National Capabilities Program, or TENCAP.[111] TENCAP is also a 'black' program, and so will not be discussed in detail here. In general, its goal is to identify ways in which the information provided by the national RSTA assets can be made readily available to tactical users. It has proved to be an extremely beneficial program, and so has received a great deal of emphasis by the Army. TENCAP's budget was $77 million for FY84, and had climbed to $120 million by FY86.[112]

Weather & Earth Sensing

In addition to RSTA satellites dedicated to military purposes, the U.S. has also launched a series of satellites designed to observe the earth and provide data on mineral deposits, pollution sources, crop forecasting, etc. This series, known as Landsat, became operational in 1972. Since then five Landsats have been placed into polar, sun-synchronous orbits; a sixth is under development. The first three of these five had a 80 meter resolution capability; the newest two have 30 meter resolutions. Only one of these five still remains operational. In 1984, Congress legislated to privatize Landsat; its operation was turned over to the Department of Commerce, which selected a contractor, the Earth Observation Satellite Company, or EOSAT, to commercialize the system. Although this transfer did not go smoothly, Landsat now provides satellite imagery to anyone for a fee. As such, it is in direct competition with the French SPOT satellite, and with the Soviet Soyuzkarta,[113] which will be discussed later in this chapter. The Army is one of its customers, and uses Landsat products for mapping and limited reconnaissance purposes. Landsat pictures were the first to publicly show the oil spill which was released into the Persian Gulf in February 1991 during Operation DESERT STORM.[114] Landsat has also become relatively profitable, with revenues of $29 million in 1989, approximately $35 million in 1990, and $42 million forecasted for 1991.[115]

Weather forecasting is an important part of military planning, and the ability to do it well and accurately is much desired. The decisions of theater commanders are heavily influenced by such environmental factors as the quality of atmospheric communications, performance of high-technology weapons such as lasers, night-vision devices and guided munitions, trafficability of terrain, and the effects of heat, rain and cold on soldiers.[116] Timely, accurate weather data becomes essential.

Typically, weather satellites are launched into sun-synchronous orbits so that they pass over the same point of earth at the same time each day. Such orbits are high inclination, generally about 100°, generally circular, with an orbital altitude of between 500 and 1500 km. This allows details of cloud cover to be observed, yet permits wide views.[117]

The three goals of Army weather forecasting are specified in "The Army's Space Architecture" as:

- determining weather effects on unit and weapon effectiveness
- providing terrain data for analysis and operational planning
- providing integrated weather/terrain effects[118]

The space system used to achieve these goals is known as the Defense Meteorological Satellite Program (DMSP). DMSP currently uses satellites developed by RCA known as the Block 5D-2; these are sometimes called METSTAR.[119] The program is controlled by the Air Force from Offutt AFB, Nebraska.[120] These satellites work in pairs, orbiting in 450 mile polar sun-synchronous orbits.[121] Each carries sensors designed to develop the weather imagery and data necessary to support space launches, tactical ground, sea and air operations, and photo-reconnaissance missions. These sensors include an operational linescan system, an infrared temperature and moisture sounder, a microwave temperature sounder, a precipitating electron spectrometer to gather solar flare effects data, and a microwave imager. Future upgrades of the DMSP satellites, known as the Block 6 series and scheduled to be launched about 2003, are to include laser hardening, electromagnetic pulse hardening, and improved anti-jam capability.[122]

DMSP transmits meteorological data to both fixed and mobile receiving terminals. The mobile, or tactical, terminals can receive real-time weather data whenever a satellite is in view. Typically, this is four times per day. 34 of these tactical terminals are operated by the Air Force, with seven of them dedicated directly to support of Army operations. The transmitted data includes visual and infrared views with resolutions of about .3 nautical miles.[123] To obtain this weather data, the Army must request it from the Air Force.

Data provided by DMSP satellites has been directly utilized by Army ground forces during tactical operations. During Operation JUST CAUSE in December 1989, a weather satellite provided imagery to U.S. commanders which indicated icing conditions on a proposed hilltop airstrip. Based on this information, operations were shifted to another area. During Operation DESERT STORM, DMSP satellites monitored weather patterns in case of chemical attacks. Tactical terminals which can provide such data in real time to local commanders and theater commanders are now being fielded.[124]

The Army has also experimented with obtaining weather information from commercial satellites. In a test conducted by U.S. Army Europe (USAREUR), tactical units were provided with two types of commercial meteorological receivers, the Automatic Picture Transmission (APT) terminals and Weather Facsimile (WEFAX) terminals. These could obtain near real-time weather information with resolutions on the order of 4 to 8 km from a variety of civilian weather satellite systems, such as geostationary satellites like GOES, the European METEOSAT, or the Japanese GMS; or sun-synchronous satellites like TIROS or the Soviet Meteor.[125]

U.S. civilian weather satellites are managed by the National Oceanic and Atmospheric Administration and operated by the National Aeronautics and Space Administration. NOAA controls two Television and Infrared Observation Satellites (TIROS) orbiting in sun-synchronous polar orbits, while NASA controls two Geostationary Operational Environmental Satellites (GOES), which provide high resolution visual and infrared imagery, orbiting in GEO. The NOAA satellites transmit weather data continuously. This information is available to anyone equipped with a compatible receiver. NASA provides the information from TIROS to companies world-wide via APT ground terminals.[126]

Geodesy & Mapping

The U.S. goes to considerable effort to gather data about the earth. This data takes the form not only of the actual topography of the earth's surface, but also about the make-up of the earth's crust and variations in its density and gravitational field. All such data has many military applications, not the least of which is for ballistic missile targeting.

Until recently, there had been no publicly released information regarding any U.S. satellites engaging in actual mapping operations, although it had been suggested that earth sensing satellites, such as Landsat or SPOT, could perform mapping functions, particularly if multispectral imagery was used. As reported in Military Space, however, Army Topographic Engineers used imagery obtained from Landsat's thematic mapper to produce 1:50,000 scale maps during Operation

DESERT STORM. Often the Landsat images were enhanced by the Defense Mapping Agency by combining them with imagery purchased from SPOT. The map production was also aided by the use of GPS receivers to determine control points for field surveys. The quality of these maps was good enough that, once in the hands of the troops, they were used to determine ways to breech the Iraqi defenses and to determine how to seize and refurbish Iraqi air bases for use by U.S. C-130 transports.

The Army does not presently possess space-based terrain mapping and evaluation capabilities of its own. However, the Army Corps of Engineers and the Engineer Topographic Laboratories are working on a satellite terrain data and multispectral imaging system for future use.[127]

Thus far, those systems which make up the space segment of the U.S. space infrastructure have been discussed. The United States possesses well developed communications, navigation, reconnaissance and surveillance, and weather and earth sensing systems, and is beginning to investigate the feasibility of producing militarily usable maps with space assets. However, for any of these satellites to be of any benefit at all, they must be somehow placed into orbit. This next section discussing the "Space Capabilities of the United States" will describe the launch systems which the U.S. employs to do that.

U.S. LAUNCH SYSTEMS

The other half of any space infrastructure is the system which actually places the satellite into orbit. In the United States, this ability to launch spacecraft has largely been developed on the basis of peacetime requirements. In the words of General John L. Piotrowski, former Commander-in-Chief of USSPACECOM and the North American Aerospace Defense Command (NORAD), "the U.S. space launch infrastructure is a peacetime system operated by research and development organizations in response to a program of planned and budgeted launches based on authorized on-orbit constellations and their scheduled replacement requirements."[128] Until recently, much of the nation's launch capacity has resided in the Space Transportation System (STS). This policy has been rethought following the explosion of the Challenger in 1986, and the U.S. is now in the process of fielding new launch systems to more effectively distribute our launch requirements among distinct, yet redundant, launch systems.

The U.S. currently employs six separate launch systems. The Air Force is responsible for the launch of all U.S. military space systems, while NASA handles civil sector launches. The smallest booster, the Atlas E, can lift a 1800 pound payload to low earth orbit (LEO). The largest is the shuttle itself, which is currently the world's only reuseable booster. New or redesigned boosters, such as the Titan II and Titan IV, and the Delta II, have been developed and successfully flown since the Challenger explosion, and are now launching much of DOD's payloads.[129] Both the Delta II and the Titan IV became operational in 1989. Generally, each booster is dedicated to launching a specific type of satellite, although this is not necessarily a hard and fast rule. As such, from smallest to largest, the Atlas E carries weather and scientific packages; the Titan II, originally designed as a ballistic missile, carries weather satellites; the Delta II is the primary NAVSTAR booster, although it also carries communications and weather satellites; the Atlas II carries DSCS satellites to GEO; and the Titan IV and Shuttle carry a variety of satellites because of their large lift ability.[130] The Titan IV is foreseen as the workhorse of the U.S. rocket fleet for the coming decade. First launched in June 1989, it not only can lift payloads with large volumes, as the Shuttle can, but it can place a 10,000 pound payload into GEO. The shuttle is incapable of reaching such high orbits, unless the payload is attached to an inertial upper stage which can boost it higher once the Shuttle has released it. Further upgrades of the Titan IV's solid rocket motors may ultimately allow 40,000 pound payloads to be placed into low earth orbit.[131]

In the commercial space sector, private companies are attempting to market launch services, using either Atlas, Delta, or Titan boosters, or privately developed commercial vehicles. None have been launched yet. In the civil space sector, NASA has begun development of the Advanced Launch Development Program (ALDP), formerly known as the Advanced Launch System (ALS), which is a heavy lift system planned to be operational sometime after the turn of the century. Its goal is to reduce current payload cost per pound figures by a factor of ten, although DOD considers that a reduction of 3 to 5 times is more likely to be achieved.[132]

The United States operates four launch sites. The two major ones are the Kennedy Space Center at Cape Canaveral, Florida; and Vandenberg AFB in California. Generally, Kennedy launches NASA spacecraft and Vandenberg launches DOD payloads, although this is not absolute. Also, Kennedy is typically used to place satellites into low inclination LEO or to GEO, while Vandenberg is better for placing them into polar orbits. A third launch site is operated at Wallops Island, Virginia; this is primarily for small scientific packages. A fourth site at White Sands, New Mexico is used for short-range, vertical experiments; no orbital flights are initiated there.[133]

In general, the military believes that the U.S. launch capability is presently inadequate to effectively support U.S. forces during a general war. The relatively small stable of launch vehicles, and the extremely limited launch facilities, contribute to this belief. The military, and SPACECOM in particular, is attempting to develop programs to compensate for these deficiencies. Some of these programs will be discussed in the following section.

U.S. DEVELOPMENTAL PROGRAMS

In addition to the basic elements of the nation's space infrastructure, the satellite constellations and the launch systems which place them in space, the U.S. also directs a considerable amount of effort and resources to rectify perceived deficiencies in its space program. Chief among these deficiencies are an insufficient launch capability, the vulnerability of U.S. satellites to hostile action, the lack of a defense against ballistic missile attack, and the inability to effectively accomplish required space control operations. The developmental programs which are designed to provide solutions to these problems will be discussed briefly in this section.

LIGHTSAT

A continuing concern about U.S. space capabilities has been the ability of the United States to survive an attack on its space-based assets. Although the Soviet Union is currently the only nation possessing an operational ASAT capability, the proliferation of satellite launchers throughout the Third World can conceivably enable many other nations to gain that ability in the near future. The development of a U.S. ASAT capability is one response to this threat; another is to develop the capacity to orbit a large number of relatively inexpensive, single-function tactical satellites very quickly during a crisis to augment or replace any satellites which are destroyed or rendered inoperative. The development of these LIGHTSATs, or CHEAPSATs as they are sometimes called because their costs are expected to be relatively inexpensive compared with standard satellites, will give the United States a 'surge' launch capability. Their development has become a high priority program for U.S. space planners.

The development program for LIGHTSAT, formally known as the Advanced Satellite Technology Program, falls under the auspices of the Defense Advanced Research Projects Agency (DARPA). Ideally, the final product of this program will possess the following general characteristics:

- light weight: 300 to 500 pounds
- tailored for specific missions, e.g. communications
- short-lived: 6 to 18 month operational life on orbit
- high, but not exceptional reliability: 90% vs 99%
- launch-on-demand capability
- transportable missile and mobile launch system
- survivable in a directed energy weapon environment
- relatively inexpensive[134]

Proposed uses for lightweight satellite technology includes multi-channel EHF communications satellites which would be compatible with and could be used as a supplement for MILSTAR; components of a distributed constellation as part of a space-based radar system; target acquisition sensors, using visible and infrared optics; and as elements of a space-based antenna network.[135]

As currently envisioned, the system would use mobile launch platforms to reduce fixed pad vulnerability, much as a Pershing missile battery used to do. It is believed that such a system could launch a satellite on 72 hours notice.[136] The satellites which would be lifted into orbit would typicaly weigh only about 400 pounds; the missile itself would weigh about 70,000 pounds. Design specifications call for the missile to be initially capable of inserting the satellites into a 400 mile polar circular orbit; the ultimate goal is a payload weight of 1500 pounds. It has been estimated that about 90% of the required technology for the program is already available, and can be used 'off the shelf.'[137] The satellites themselves would be capable of accomplishing communications and navigational missions, and would be used to augment existing constellations or replace those type satellites which had been destroyed. Additionally, some types would provide a sensor ability for weapons targeting.[138] Conceivably, LIGHTSATs could provide theater commanders with direct control over their space-based communications and reconnaissance assets, although there would be no requirement for them to be launched from within the theater.[139]

Ideally, each LIGHTSAT launched to supplement or replace an existing space system will be cheaper than the ASAT missile launched to destroy it. In this way it becomes cost prohibitive to initiate an attack in space. The goal now is for each LIGHTSAT launch to cost about $10 million, an extremely inexpensive pricetag in terms of space systems in which satellites typically cost in excess of $50 million apiece.[140] Funding for the program has remained constant, but meager, over the past two years. Total budget allocations for FY88, FY89 and FY90 were $35 million each year. In FY90 this represented about .2% of the DOD space budget.[141]

The Army, Navy and Air Force are all currently involved in LIGHTSAT development programs, although each service envisions different roles for these systems. The Army's program, run by the Communications-Electronics Command (CECOM) in Fort Monmouth, New Jersey, views LIGHTSATs as a means to place space communications and reconnaissance assets directly in the hands of the theater commanders; it anticipates being able to conduct a joint demonstration launch with DARPA in 1994.[142] Lightweight satellites will provide 30 narrowband secure voice or data channels, plus medium data rate channels to support the Mobile Subscriber Equipment communications system. The program includes the development of small ground terminals which will make the LIGHTSAT interoperable with MILSTAR.[143] The Navy is developing a satellite called the Passive Radio Frequency Interference Location Experiment (PROFILE), although no details of its design or function have been publicly released. The Air Force prefers to call its lightweight satellites 'Tacsats', for Tactical Satellites. Their function is to provide replacement capability for systems which are destroyed during conflict, or augmentation during crisis. It is estimated that such replacement satellites could be in production by 1995, and that their primary designs would be for reconnaissance.[144]

DARPA has already begun to test the concept. Using the Pegasus air-launched vehicle, three preliminary systems tests have been conducted beginning in November 1989 and continuing up to the spring of 1990. The Pegasus is carried under a B-52, then launched while airborne to place its payload into orbit. In its present form, the Pegasus is 49 feet long, 4.2 feet in diameter, weighs 41,000 pounds and is designed to carry a 900-pound payload.[145] The first two systems tests investigated the aerodynamics of carrying the Pegasus beneath a B-52. On the third systems test, a small Navy communications satellite was orbited to test the viability of a LIGHTSAT. The next scheduled systems test is planned to place seven small 'micro-sats,' UHF communications satellites weighing 50 pounds each, into a 400 mile circular orbit. A follow-on test, dubbed the standard small launch vehicle (SSLV) or Taurus rocket, will have a Pegasus launcher atop a M-X missile first stage. This sytem is intended to be able to place a 1500 pound payload into low earth orbit, or smaller payloads into semi-synchronous or geosynchronous orbits.[146]

Some experts are critical of the LIGHTSAT concept. Estimates have been made which indicate that when launch support costs are included, LIGHTSATs might even be more expensive on a cost per pound of payload basis.[147] Charges have been made that LIGHTSATs are redundant systems with limited capabilities and limited operational lives.[148] One critic claimed that 200 LIGHTSATs would be required to replace the Navy's FLTSATCOM UHF follow-on system should that be destroyed during a conflict.[149]

Anti-Satellite Systems

The Defense Department has the responsibility for maintaining space control. These responsibilities include assured U.S. access to space, the ability to deny access to space of potential adversaries, ensuring the survivability of U.S. space systems, and the ability to detect and react to attacks on our space systems. In order to attain the ability to deny access to space by others, the U.S. has begun the development of an Anti-Satellite capability. As specified in the National Space Policy statement of 1989, "the United States will develop and deploy a comprehensive [ASAT] capability with programs as required and with initial operations capability at the earliest possible date."[150] The Army has been designated the DOD proponent for this program.

The Army's ASAT is not the first anti-satellite system for the United States. The first U.S. ASAT test actually occurred on 13 October 1959, when a Bold Orion air-launched missile demonstrated the feasibility of the concept by achieving an intentional near miss on the U.S. Explorer 6 spacecraft. Subsequent systems, notably the SAINT program, which ran from 1960-1962 but never got off the ground, and systems using Nike-Zeus and Thor missiles, which ran until 1975, were tested by the United States. Ultimately, it was decided that all of these systems violated the 1963 Limited Test Ban Treaty and the 1967 Outer Space Treaty, and all were terminated. In 1977, the Pentagon determined that the Soviet Union possessed an operational ASAT, and the President authorized DOD to develop a comparable U.S. system. This system was another air-launched missile which was to be deployed from a F-15. Five U.S. tests of this system were conducted between 1984 and 1986. Although these tests demonstrated the feasibility of the system, in 1988 Congressional opposition to testing the system against objects in space caused DOD to cancel the project.[151]

In March 1989, DOD allocated funds and assigned the mission of establishing a joint program to develop the nation's ASAT capability, and the requirement to provide a program manager for it, to the Army's Strategic Defense Command (SDC).[152] This joint program was initially funded at $73.9 million for FY90, and was subsequently increased to $207.8 million for FY91.[153] The initial focus of the ASAT program has been on kinetic energy technologies, which rely on impact as the kill mechanism, although future work may be conducted on directed energy lasers. Much of the technology to be used for ASAT will come from the nation's SDI program. Says LTG Robert D. Hammond, Commander of the SDC: "DOD's direction for ASAT is to leverage to the maximum extent possible off the technology programs of SDI, while strictly complying with all applicable treaties."[154]

The ASAT system which the Army SDC is developing is a ground-based, hit-to-kill, direct ascent weapon system, designed to be a kinetic kill interceptor which can destroy satellites without resortng to a nuclear warhead. Plans currently call for this system to be operational by 1996.[155] To track hostile satellites prior to destruction, the ASAT program will use many of the same systems as the SDI. One such system is the Ground-Based Radar (GBR), which is to be tested on Kwajalein Atoll in 1993. Up to ten operational versions of these radars are expected to be fielded by the mid 1990s. These versions could possibly be mounted on rail cars for mobility and survivability.[156] The ASAT missile itself will use infrared and visual optical sensors, and have an inertial guidance system that is coupled with GPS. Ideally, it will weigh about 150 pounds, be capable of limited maneuvering during flight as it tracks its target, and be able to engage targets at ranges in excess of 3000 kilometers. Currently, planners envision the system being fielded at a single site in the United States.[157]

Generally, it is anticipated that the U.S. ASAT will have an operational ceiling of about 500 km. By comparison, the Soviet ASAT is thought to have a ceiling of 1500 km. These altitudes are important to consider because they dictate which types of satellites the ASAT systems can engage. Soviet satellites orbiting at altitudes of 500 km or less are typically meteorological, reconnaissance and navigation types. Additionally, satellites in so-called 'Molniya' orbits descend to approximately 500 km twice per day, although their perigee is over the Southern Hemisphere and would have to be engaged by ASATs launched from sites outside of the United States. The Soviet Union places its early warning satellites and the majority of its communications satellites in 'Molniya' orbits. A handful of communications satellites orbit in GEO at altitudes of about 36,000 km, and the new Soviet navigation system, GLONASS, orbits at about 20,000 km. The United States, on the other hand, has very few satellite systems which orbit at altitudes lower than 1500 km. U.S. RSTA satellites typically orbit at about 500 km; all others by and large orbit much higher. U.S. navigation satellites, the NAVSTAR/GPS system, operate in semi-synchronous orbits at 20,000 km. Most U.S. communications satellites are in GEO at 36,000 km, as are most U.S. weather and early warning systems.[158]

The Strategic Defense Initiative

The United States launched its Strategic Defense Initiative (SDI) following a speech by President Ronald Reagan on 23 March 1983. In it, President Reagan challenged the U.S. to develop an active defensive means to protect the nation against ballistic missile attack, a deliberate shift in U.S. strategy away from that of Mutually Assured Destruction (MAD). Within a year, the Strategic Defense Initiative Organization (SDIO) had been set up and "chartered to explore advanced non-nuclear technologies associated with defense against ballistic missiles."[159] The SDIO promptly set up a program which would, in theory, allow the US to capitalize on its technological prowess to build a layered defensive system of space-borne and ground-based sensors coupled with weapons systems and battle management elements which would be capable of destroying adversary missiles in flight.[160] This Space Defense System (SDS), or 'Star Wars' as it is more popularly called, faces serious technical criticisms from the scientific community regarding its feasibility; legal questions about its compliance with the 1972 Anti-Ballistic Missile Treaty; and even more importantly, severe budget battles both within Congress and in the Defense Department itself as SDS competes for limited funds with other high-dollar programs.

As presently conceived, the SDS consists of a defense which engages missiles during each phase of flight. Generally, the flight of a ballistic missile is broken into four distinct phases: the boost phase, from the time the missile leaves its silo or launcher until it reaches the top of the atmosphere, lasting about 5 minutes; the post-boost phase, during which the warhead platform, or bus, of the missile follows a ballistic trajectory toward its target area, lasting about 5 minutes; the mid-course phase, during which separate warheads and decoys deploy from the bus and move on independent trajectories, lasting about 20 minutes; and the terminal phase, from re-entry into the atmosphere until impact, lasting about 5 minutes.[161] The best time for a missile kill is during the boost or post-boost phase. Since Soviet missiles can carry ten or more warheads and decoys, a successful interception in these phases can potentially eliminate many more threats than a successful interception later on.[162] After these phases, the problem becomes exceedingly difficult because of the number of incoming warheads and the distractions of the decoys.

The SDS concept envisions a multi-layered defense to engage targets during each of these four flight phases. The primary means of engagement during the boost phase is either a kinetic energy (KE) weapon or a directed energy (DE) weapon, with the intention of destroying as many missiles as possible to make the task easier for the other layers of the defense. During the post-boost phase, the weapon of choice is a KE weapon, with the intention of destroying the warhead platform before the individual warheads and decoys can be released. During the mid-course and terminal phases, ground-based missiles would engage the incoming warheads.[163]

Current R&D efforts to make the SDS concept a reality consist of five elements. They are:

- Surveillance, acquisition, tracking and kill assessment sensors
- Non-nuclear, kinetic energy weapons
- Directed energy weapons
- Development of key technologies to assure survivability and lethality
- System analysis and battle management[164]

The basic philosophy of the SDIO is to "build upon existing technologies, and identify and develop emerging technologies that can be applied, even though they may involve higher levels of technical risk."[165]

At present, several components of the SDS are beginning to move from the R&D phase to the actual validation phase of the acquisition process. The Boost Surveillance and Tracking System (BSTS), a space-based surveillance system designed by Lockheed Missile & Space Company and by Grumman Aerospace, detects the exhaust plumes of ballistic missiles as they are launched and then tracks, counts and identifies the types of missiles in the attack. The Space-Based Surveillance and Tracking System (SSTS), a mid-course sensor system designed by Lockheed and TRW, tracks warheads as they move through their trajectories. The Ground-Based Surveillance and Tracking System (GSTS), a late mid-course tracking and target discrimination system, is intended to supplement the SSTS elements. Space-Based Interceptors (SBI), a constellation of killer satellites in low earth orbit, are designed to engage warheads in the boost, post-boost and mid-course phases of flight. The Exoatmospheric Re-Entry Vehicle Interceptor System (ERIS), is a ground-launched interceptor designed to destroy incoming warheads during the late mid-course phase. The Battle Management/Command, Control and Communications System (BM/C^3), is the master control which would monitor and control the activities of all components of the SDS. Additionally, a Ground-Based Radar system (GBR) is being considered for employment during the late mid-course and terminal phases to discriminate and track re-entry objects which still survive by that point.[166] These objects would then be destroyed by the High Endoatmospheric Defense Interceptor (HEDI), a supersonic ground-launched missile. The Army is responsible for the research and development programs of the GBR, the GSTS, the ERIS, and the Army portion of the BM/C^3.[167]

At the present time, it is generally conceded that the current state of the SDS battle management ability is inadequate.[168] It has been estimated that one hundred million lines of computer programming, taking 30,000 man-years of work to complete, will be required for such a system to be equal to the task. If printed out, this would fill three million pages. Additionally, the control system must be made sufficiently redundant to guarantee its success.[169] A considerable amount of effort is being put into the development of the BM/C^3 to rectify this situation.

'Brilliant Pebbles' is the name given to the space-based constellation of killer satellites which will be capable not only of detecting, tracking and acquiring hostile missiles, but also of destroying them. The name comes from the satellites' small size, weighing roughly 80 pounds, and their on-board computer. Characterized as a 'Cray-in-a-can', this miniaturized computer will permit the pebble to do its own warning, attack assessment, and target selection. It essentially is an independent ballistic missile killer which does not require centralized control and direction once it has been given release for engagement action.[170] To detect a missile launch and then distinguish valid targets from decoys, each pebble is equipped with a sensor system which will permit observations in the visible light region with less than 1 meter resolution. Some consideration is also being given to equipping them with radar systems which will permit observation through cloud cover.[171] It is thought that these satellites will be deployed in a worldwide constellation which has each satellite within a few hundred kilometers of another. Such coverage will be possible because of the satellite's low cost, roughly $1 million per copy, and its ability to operate efficiently at extrememly low altitudes because of its reduced drag profile.[172]

In addition to the 'Brilliant Pebbles' satellites, two types of ground-based KE weapons, designed to complement each other as one weapon system, are in the research and development stage. The Lightweight Exoatmospheric Advanced Projectile (LEAP) is designed to be a low-cost projectile used to acquire, track and intercept incoming ballistic missiles. Additional help for LEAP would come from the Hypervelocity Gun (HVG), initially to be employed as a ground-based system, but ultimately to be placed in space.[173] The HVG, known as the Thunderbolt, is an electro-magnetic rail gun which fires a lightweight projectile at extremely high velocity. When operational this gun will have a 48 meter barrel, fire a .25 kg discarding sabot round with a muzzle velocity of 14 km per second and be capable of firing a large number of projectiles per second. Tests on scaled down versions of the HVG have fired a 115 gram projectile at a velocity of 4.3 km/s; further developmental work is ongoing.[174] It is felt that the power generation system for the gun is the key technology which must be developed. A muzzle energy of 60 megajoules is required to achieve the desired muzzle velocity. The generation of such energy can only be accomplished by nuclear generators and much improved capacitors. The development of these systems is being conducted by DARPA, the Department of Energy, and NASA.[175]

In addition to the projectiles which kill with kinetic energy, several types of ground-launched missiles are under development. ERIS is a ground-launched missile designed to be a low-cost means to destroying incoming missiles in the mid-course phase. The $500 million project is being managed by the Army for the SDI Organization. Initial developmental flight tests of this interceptor were conducted during 1990 from Mech Island on Kwajalein Atoll. In this test, ERIS successfully intercepted and destroyed a dummy reentry vehicle launched from Vandenberg AFB in California.[176] The ultimate aim of this project is a ground-based interceptor which can acquire and track a target, provide terminal maneuvering and destroy the target by a direct-impact intercept.[177]

HEDI is a Mach 15 interceptor designed to destroy targets as they enter the terminal phase. Its operational regime is below 200,000 feet altitude. To acquire its targets, HEDI uses sensor data from airborne and ground-based systems, such as the GBR, to enable it to discern between actual warheads and decoys.[178] Some work is presently proceeding which would extend the range and altitude of HEDI by incorporating a dual-pulse, solid fuel second stage into its design.[179]

One spin-off from this missile development which has applications for theater commanders and Theater Missile Defense (TMD) is the Extended Range Intercept Technology (ERINT) program. This concept foresees a small, agile, lightweight missile designed to destroy tactical ballistic missiles by direct impact. Fire control software for the system, currently under development, would be compatible with already fielded tactical air defense ground radar systems.[180]

Chemical and free electron lasers are being evaluated for use in ground and space-based directed energy systems, both as weapons and as radars. A feasibility demonstration of a chemical laser indicated that much less power was required to destroy missiles than anticipated; demonstrations for a free electron laser expect to show similar results.[181] However, it is generally conceded by proponents and opponents of SDI alike that about 100 space-based laser stations would be required to effectively engage large numbers of incoming missiles.[182]

Additionally, SDIO is actively exploring concepts for space-based neutral particle beam weapons (NPB), in which neutral hydrogen ions are accelerated toward a target. On impact, these particles would permit sensors to distinguish between actual warheads and decoys by the amount of neutrons and gamma rays emitted; the NPBs then could be employed to destroy the warheads, either by structural melt, high-explosive detonation or electronic disruption.[183]

SDS has received a great deal of criticism regarding its compliance with the intent of the 1972 Anti-Ballistic Missile (ABM) Treaty which the United States signed with the Soviet Union. This treaty prohibits both nations from developing, testing or deploying an ABM defense system which has space-based components. While much of the debate over compliance with the treaty revolves around the semantics of the its provisions, most analysts feel that research and experimentation is not a violation and that a ground-based limited ABM protection system could be made treaty compliant. The Defense Department has emphasized the distinction between research and development, indicating that the threshold between the two would be crossed when a prototype is constructed and tested. Currently, as mandated by DOD Directive 5100.70 "Implementation of SAL Agreements", dated 1973, the SDIO must certify its compliance with the ABM treaty provisions to DOD each quarter.[184] Ultimately, if the SDS is deemed to be in conflict with the provisions of the ABM Treaty, the United States is legally empowered by the provisions of the treaty to ask that it be amended, or to withdraw from the accord with six months notice.[185] It is generally agreed that all current SDI work is in full accord with the provisions of other treaties to which the U.S. is a signer, specifically the 1963 Limited Nuclear Test Ban Treaty and the 1967 Outer Space Treaty.[186]

Funding remains a significant problem for the realization of the SDS. As shown previously in Table 1 on page 34, appropriations by Congress have been less than budget requests each year since the SDIO's first budget submission for FY 1985, and it is unrealistic to expect that that trend will not continue. As a point of comparison by which to measure the size of the expenditures on SDI, the budget appropriation for the SDI program in FY91 is $2.9 billion, representing approximately 21% of NASA's FY91 budget appropriation of $13.88 billion.[187] Similarly, it accounts for approximately 40% of DOD's space R&D budget for FY91.[188] In general, Congress does not always see eye-to-eye with SDIO planners, and Congressional opposition to the expensive SDS programs may be expected to continue.[189]

There is evidence to indicate, however, that current research efforts will result in lower costs for the completed system. As an example, the cost of an individual pixel of a mercury cadmium telluride infrared detector, which is the main sensor type used in the BSTS, was some $20 in 1984. By 1990, the price of a pixel has been reduced to $5 each, and it is anticipated that that cost will drop by a factor of 10 in another five years. At the same time, the effectiveness of the system composed of those pixels has risen from about 3% a few years ago to nearly 30% now. Further increases are expected.[190]

As a consequence of budget restrictions, and also partly in recognition of the magnitude of the technical problems to be solved to achieve an operational SDS, the SDIO has recently indicated that the program would be down-sized and called the Protection Against Accidental Launch System, or PALS. The Army routinely uses the term Limited Protection System (LPS) for this scaled-down version of the SDS.[191] In LPS, emphasis would be shifted away from complete protection against a massive Soviet ballistic missile attack, and instead focus on protection against only a few accidental, or unauthorized, Soviet and/or Third World launches. The size of the program, and the money required for it, would be commensurately scaled-down. As an example, instead of employing 4600 space-based interceptors costing $55 billion as envisioned by the current SDS, the LPS would require less than 1000 interceptors at a proportionate cost.[192]

Although first regarded with extreme pessimism by the scientific community, much of their initial criticism has proved to be either unfounded or has been overcome by technological and research advances. Consequently, 'Star Wars' has begun to look more and more like a viable concept, particularly when viewed against a limited attack. As is stated by defense analyst Kim Holmes, quoted in The Intelligent Layperson's Guide to 'Star Wars': "The feasibility of SDI is slowly and inexorably becoming not a matter of 'if' but of 'when'."[193]

FOREIGN SPACE ACTIVITIES

Naturally, the potential of space has not escaped the attention of other nations around the world. Indeed, several nations have developed space capabilities which must be considered a potential threat to U.S. space interests, and their numbers continue to grow. If the U.S. is to continue to operate in and exploit space, it must keep these potentially hostile capabilities in mind.

SOVIET SPACE CAPABILITIES

The Soviet Union currently is the nation which poses the single-most dangerous threat to the security of the United States. Its space program is designed to fully support its national security objectives. In 1987, Secretary of Defense Caspar Weinberger said:

> For the past three decades, since the inception of the space era, the Soviet Union has worked steadily to acquire a military capability in space. Because the Western democracies, particularly the United States, have directed a large part of their space resources and technology toward other goals, and sometimes have lacked clear goals, we have allowed the Soviet Union to come dangerously close to achieving its military objectives in space. The Soviets have methodically designed their space systems to fight a war in space. For over 30 years, Moscow has worked steadily to acquire the capability for military control of space. . . . the Soviets' efforts have been impressive indeed.[194]

The United States is only now beginning to come to grips with this threat.

Throughout the years, the Soviet Union has competed more or less successfully with the United States in the space race, and all the while has recognized the potential uses of space for military purposes. As stated in the Soviet Dictionary of Basic Military Terms as early as 1965, ". . . mastery of space is an important prerequisite for achieving victory in war."[195] Consequently, the great majority of its space programs have military applications, despite the fact that the existence of their military space program was not publicly acknowledged until 1985.[196] Since the launch of Sputnik on 4 October 1957, the Soviet Union has made steady and continual progress in its development of its space program. Its COSMOS satellites, a series of reconnaissance and surveillance satellites, were first launched in the early 1960s. In 1965, the Soviet Fractional Orbit Bombardment System, intended to place a nuclear weapon in orbit which could then deorbit and land on a terrestrial target, was discovered. An anti-satellite system became operational in 1971. A more or less permanent manned presence in space was achieved in 1972 with the orbit of the first Salyut space station; this presence has evolved into the current Mir. Its launch abilities have been significantly improved and increased. U.S. strategic planners now recognize these facts and are planning against them.

Soviet Launch Systems

General John L. Piotrowski, former Commander in Chief of U.S. Space Command and NORAD, has declared that "the Soviet launch infrastructure is the most responsive in the world."[197] Total Soviet launches exceeded U.S. launches in 1967 and has been nearly an order of magnitude greater ever since.[198] Currently, the Soviets annually launch more than 100 space vehicles from approximately 20 launch pads at three cosmodromes; this number is five times more than that of all Western nations combined.[199]

The primary launch site for piloted, lunar, planetary and geostationary satellites is at Baikonur Cosmodrome, near Tyuratam in Kazakhstan. This is the site from which Sputnik 1 was launched on 4 October 1957.[200] A large military launch site is located at Plesetsk, south of Archangel in European Russia. This site has the distinction of being the most prolific launch facility in the world today.[201] The third site is located near Kasputin Yar, close to the Caspian Sea, and deals typically with vertical probes and small payloads.[202] Generally, estimates of the percentage of Soviet launches which have military applications range anywhere from 75% to 95%.[203] During crisis periods, the frequency of these launches can be greatly increased, with launches being made within a matter of days, or even hours.[204] Comparitively, it currently takes the U.S. months to replace a malfunctioning or inoperative satellite. As two examples of this responsive Soviet launch capability, following the catastrophic failure of a navigation satellite in 1981, a replacement was in orbit in less than two months;[205] and during the Falkland Islands conflict in 1982, 28 spacecraft were orbited by the Soviets in just 69 days.[206] In 1989, the military cosmodrome at Plesetsk accounted for nearly 61% of all successful Soviet launches.[207] It has been estimated that if their presently orbiting satellites were somehow eliminated, their launch capability is such that all of their satellite constellations could be restocked within three months.[208] The West currently has no similar surge capability.

To achieve this launch capability, the Soviets have developed a stable of eight different booster types, and are developing at least two more. These range in size and payload capacity from the SL-8, which can deliver approximately 1700 kg to a 185 km orbit, to the giant SL-X-17, known as the _Energia_, which is capable of lifting in excess of 100,000 kg to a 185 km orbit. By comparison, the U.S. possesses only five launch vehicles, the heaviest being the Space Shuttle which is capable of lifting 26,000 kg into orbit.[209] At the same time, Soviet satellites have shown a marked improvement both in their capabilities and their operational lifetimes. Until recently, the typical Soviet satellite was designed to function on orbit for six to nine months; indeed, some were expected to last only from two to eight weeks. This accounted in part for the requirement for a high launch capability. More recent launches, though, have indicated satellites with design lifetimes of approximately a year.[210] Consequently, the number of operational Soviet satellites on orbit increased from 120 in 1982 to 150 in 1987 and is expected to be greater than 200 by the turn of the century. By comparison, the total number of operational U.S. satellites remains fairly constant at approximately 80. This number was surpassed by the Soviets in 1972.[211] All of this contributes to the threat to U.S. space systems.

The Soviets have recently begun offering their launch services on a commercial basis. The primary booster being offered for this purpose is known as the Zenit. It is a medium-lift rocket which first became operational in 1985. It burns a mixture of kerosene and liquid oxygen, and is also used as a strap-on booster for the Energia. It is capable of placing a 16 ton payload into LEO. This is the booster which the Australians hope to launch at Cape York;[212] that effort will be described later in this section.

Soviet Satellite Systems

Soviet satellite systems, much like those of the United States, are capable of providing space support to operational military commanders. This support comprises:

- target location, identification and characterization
- order of battle data
- force deployment/maneuver monitoring
- situation assessment
- geodetic information for tactical nuclear targeting
- mapping and positioning
- communications
- meteorological support[213]

A variety of satellite systems, again comparable to U.S. systems, provide this support. Those satellites dedicated to reconnaissance and surveillance roles are typically given the COSMOS designator. These types account for approximately half of all annual Soviet satellite launches, with an average over the last two decades of about 35 being placed in orbit each year.[214]

Two types of dissimilar but complementary satellites, , the Radar Ocean Reconnaissance Satellite (RORSAT) and the ELINT (Electronic Intelligence) Ocean Reconnaissance Satellite (EORSAT), are used specifically to locate and target naval forces for destruction. The Soviets firmly believe that their ability to counter U.S. naval superiority is dependent on these space assets.[215] Both types of these satellites orbit between 250 and 450 km and permit virtually complete monitoring of all strategic waterways. They are able to locate frigate-size ships to an accuracy of 3 km, and can provide such targeting data direct to Soviet naval units. These reconnaissance satellites are reportedly, however, somewhat hampered by the presence of cloud cover. A RORSAT, which uses a nuclear reactor to generate the high power levels required for its radars, has not been in orbit since 1988.[216]

A new generation of radar satellites, known as Almaz, meaning Diamond, is now being fielded, which does not have this limitation. A prototype has demonstrated the ability to detect underwater objects at depths in excess of 800 feet. It has also demonstrated the ability to detect sub-surface structures on land, and can resolve surface features to 15 meters with a side-looking radar. It is currently employed in conjunction with two radio-relay satellites in geosynchronous orbits which relay the Almaz imagery to earth for processing.[217] In July 1989, it revealed the additional ability to maneuver to a lower orbit, rendezvous with an unmanned spacecraft, refuel, and then re-insert itself into its preplanned orbit.[218] An operational Almaz was placed into a 300 km high inclination orbit in November 1990. This newer version is expected to have a three-year operational life. It is in an orbit such that its ground track repeats every one to three days, depending on latitude, and which allows mapping of the earth in 20x240 km sections using a synthetic aperture radar. It also has the capability of transferring data to earth in digital form from a satellite relay station.[219] The development and deployment of these satellites has raised serious concerns for the deterrent capability of the U.S. ballistic submarine force.

The Soviet Union presently employs three types of reconnaissance and surveillance satellites for surface imagery. All three are essentially modified versions of the Soyuz space capsule.[220] These satellites are capable of producing images with resolutions of .25 meters, 3 meters and 10 meters, respectively, and orbit at altitudes between 180 km and 500 km. These satellites have traditionally had very brief operational lives, although more recent launches have demonstrated real-time capacities and lifetimes of up to nine months. One of the latest of these types is reportedly designed to have an operational lifetime of nearly a year. Additionally, it possesses improved optics, a capability for real-time data transmission and the ability to make position changes in its orbit.[221] Although the Soviets typically maintain several reconnaissance and surveillance satellites in orbit at any one time, they also have the ability to launch additional satellites quickly, often within 24 hours of a world crisis.

Beginning in October 1982, the Soviets began deployment of a space-based navigation satellite system similar in purpose to the U.S. Global Positioning System. Known as the Global Navigation Satellite System (GLONASS), it is expected to be capable of providing two-dimensional navigational information to civilian and military users by 1992, and to be fully operational by 1995. Initially, 9 to 12 satellites are to be placed in geosynchronous orbits; further upgrades of the satellite constellation to 18 to 24 satellites, placed in three orbital planes, will yield a three-dimensional capability.[222] GLONASS is said to represent a virtual copy of the NAVSTAR/GPS Block 1 system. Both systems position satellites in high inclination orbits, both have satellites with 12 hour orbital periods, and both have satellites which transmit using the L_1 and L_2 frequency bands. The accuracy of the two systems does appear to be different; GLONASS is said to be comparable in accuracy to that of the degraded GPS C/A signal.[223] The Soviets have also experienced reliability problems with the system. Of the 32 GLONASS spacecraft orbited since 1982, only eight remain operational.[224]

Other Soviet satellite systems also provide weather information and communications. The weather satellites, known since 1969 as Meteor, can provide a complete meteorological picture of the world, to include ice formations in the polar regions. Three generations of Meteor satellites, each incorporting increasingly sophisticated capabilities, are currently in operation. All operate in polar orbits, just as U.S. weather satellites do. They are typically launched at the rate of one per year.[225]

Soviet communications satellites are organized in a three-tier network.[226] The lowest tier is occupied by two separate satellite constellations, designed to support world-wide tactical communications requirements. These constellations consist of small satellites orbiting in high inclination orbits, which relay routine messages using a store and dump technique.[227] The middle tier uses satellites known as Molniya, have operated since the 1960s and can now permit radio and television signals to be transmitted between space and ground stations.[228] The Molniya satellites are located in a different orbit than most communications satellites. Rather than orbiting at low altitude or at GEO, where they would appear to remain motionless in the sky, Molniya spacecraft travel in a highly elliptical orbit which has an apogee of over 40,000 km altitude over the northern hemisphere and a perigee of only 500 km over the southern. Such an orbit permits an extended 'hang time' over the northern latitudes, typically for nearly two-thirds of their 12 hour orbital period, and thus allows only four Molniyas to provide 24 hour coverage within the Soviet Union. The highest tier of the network consists of satellites orbiting at GEO. For international communications, and naturally military communications as well, satellites in GEO are more effective. The Soviets currently operate three GEO systems comprised of more than thirty satellites.[229] They also use the International Telecommunication Satellite system (INTELSAT), although they are not a member of that organization.[230]

Of particular concern to U.S. strategic planners is the Soviets' anti-satellite capability. Currently the world's only operational ASAT system, it is a ground-based co-orbital interceptor launched by the SL-11 which uses a radar sensor and a pellet-type warhead to attack targets in low earth orbit. It was first developed in the 1960s, and became operational in 1971; it has been tested operationally in space 20 times, the last being in June 1982.[231] Its kill mechanism is to maneuver close to its target, then destroy it with shrapnel from a chemical explosive.[232] The weapon's launch site appears to be the Tyuratam cosmodrome, the Soviet Union's largest; facilities there are capable of supporting the launches of several interceptors per day.[233]

The Soviets are additionally working on other systems which will have ASAT capabilities. Already in existence, although not primarily an ASAT weapon system, is the nuclear-tipped Galosh Anti-Ballistic Missile system deployed around Moscow.[234] The Soviets themselves have admitted that this system can be used in an ASAT role.[235] Systems believed to be in development include laser weapons systems, particle-beam weapons (PBW), kinetic energy (KE) weapons, and radio-frequency weapons.

The Soviet laser-weapon program, conducted primarily at the Sary Shagan Missile Test Center, is far more extensive than that of the United States, employing more than 10,000 scientists and engineers at a half dozen major R&D

facilities and test ranges. All possible types of lasers have been investigated; apparently the development of CO_2 and CO lasers has been given priority.[236] Significant technological difficulties exist which must be overcome before such a system could become functional; among these are power supply, energy storage and optical tracking systems.[237] It is believed that an operational laser weapon system could not be deployed until the late 1990s.

Research on PBWs was begun in the early 1960s, and may see an operational test in space sometime in the mid 1990s. Beams of charged and uncharged high-energy particles have been investigated. It is anticipated that several more years of research will be required before a beam capable of destroying a satellite or missile booster can be fielded.[238]

Kinetic energy weapons are those which use the energy of a high-speed collision between a satellite or missile and a small object as the kill mechanism. As with PBWs, an operational test in space for a KE system can probably not be conducted until sometime in the mid 1990s, although the Soviets have already developed an experimental 'rail' gun which will serve as the basis for such a test.[239]

Radio frequency weapons have been described as "the space weapon of the future."[240] These high-power microwave signals have the potential to destroy critical electronic components of satellites and render them ineffective and useless. Power requirements for such a system are extremely high, limiting such weapons for the time being to ground-based systems. As with the other types of weapons systems, it is thought that a radio-frequency weapon system could be operationally tested sometime in the mid 1990s.[241]

The Soviets have not proven to be forthcoming about their level of expenditures on space programs. Western analysts have routinely estimated that the Soviet Union spent about one and a half times as much as the U.S. did annually. This would amount to about $45 billion each year. Senator Alfonse D'Amato of New York, in testimony before the Defense Subcommittee of the Senate Appropriations Committee in 1987, indicated that the annual Soviet space budget was $25 billion and was increasing at a rate of 15% annually.[242] However, when the Soviets published figures detailing their space expenditures for 1989, they claimed a budget of $11 billion. This figure has been deemed not credible by the West.[243] Levels of spending are not expected to be lowered in the future, primarily because of the emphasis which is placed on space assets by the Soviets, and how heavily they rely on those assets to counter U.S. capabilities. Counter-measures for the American SDS, for example, are estimated to require the Soviet Union to invest nearly $1 trillion.[244]

The space capabilities of the Soviet Union represent a distinct and dangerous threat to the space programs of the United States. Their space support systems, provided by a robust and flexible launch capability, and a variety of reconnaissance and surveillance, communications, weather, and navigation satellites, have enhanced the Soviets' ability to target U.S. forces on earth. At the same time, their ASAT capability poses a threat to U.S. space-based assets. The Soviets themselves have claimed that space-based assets nearly double the combat effectiveness of their conventional forces. Because of this belief, budget cuts in Soviet space programs are not expected, despite the worsening Soviet economy.[245] The United States will have to monitor Soviet space programs and intentions closely over the next decade, and conduct its strategic planning for space and international commerce accordingly. In particular, the U.S. will have to keep a watchful eye on the legitimate transfer of key technology to the Soviets which may be exploited for military purposes in space. This may prove particularly difficult because the technology can be purchased from open U.S. governmental sources, and because it is sold commercially by contractors to the Soviets directly or to other nations which then pass it on.

SPACE CAPABILITIES OF OTHER NATIONS

Outside of the United States and the Soviet Union, only a handful of nations have placed satellites into orbit, and none have conducted manned flight on other than U.S. and Soviet spacecraft. However, most nations recognize the benefits of space and many intend to increase their activities in space in the coming decades.

European Space Activities

The principal 'competitor' with the U.S. and the Soviet Union in space is the European community. European space programs had budgets of nearly $3 billion in 1990, most of which represented programs run by the European Space Agency (ESA) which was formed in 1975; the remainder consisted of projects run by individual nations. As a way to compare these programs with that of the U.S., Europe launched 10 spacecraft in 1989; the US launched 24 during the same period.[246] In general, European programs are relatively inexpensive alternatives to the programs of the two major superpowers. The main difference between the programs of the superpowers and Europe's space program is that Europe emphasizes a goal of providing services to users, most of whom are commercial.[247]

European space programs include most of the elements of the superpowers' programs, the major exceptions currently being manned flight and military reconnaissance satellites. The Ariane 4 launcher is currently Europe's principal launch vehicle. First launched from the launch site at Kourou in French Guiana in June 1988 by Arianespace, the French incorporated operating company, the Ariane 4 comes in six variants, "each featuring a common three-stage rocket, with pairs of solid or liquid strap-on boosters added for higher performance."[248] The Ariane 4 is capable of delivering payloads weighing up to 4200 kg to geosynchronous orbit, at a cost per launch of approximately $84 million.[249] This equates to a cost per weight ratio of approximately $9000 per pound. By comparison, the cost per weight ratio for a U.S. Atlas-Centaur rocket is approximately $11000 per pound, and approximatley $12000 per pound for a U.S. Delta II.[250] A follow-on launcher, the Ariane 5, is currently in the third year of a $3.5 billion development program.[251] When operational in the mid-1990s, Ariane 5 will have the ability to lift a payload of nearly 17 tons to low earth orbit, or a payload to geosynchronous orbit of five tons. It will have the added advantage of being reusable.[252]

The more significant elements of the European programs are in the areas of communications and earth observation. Currently, there are nearly 20 distinct satellite communications programs being run in Europe to support the international networks of Eutelsat and Inmarsat as well as those of the individual nations and the ESA.[253] Eutelsat provides telephone, television, radio and business traffic for 26 member states in Europe, using four geosynchronous satellites; these are to be upgraded by 1992.[254] Inmarsat provides telephone, fax and data services at sea and in the air, also using a constellation of four geosynchronous satellites.[255] National communications programs include those of France, the most active, Germany, Italy, Great Britain, Sweden and Luxembourg. Of these, only Great Britain has a system dedicated to military communications, although Italy is planning to launch a military communications satellite in 1994,[256] and Spain intends to launch two aboard Ariane by 1993.[257]

Europe's earth observation satellites include what may be termed as weather and reconnaissance satellites. The principal weather satellites are the Meteosat weather-imaging satellites, which produce multi-spectral images of earth. These are to be supplemented by the European Remote Sensing (ERS) satellite, which is to "observe wave heights and wave lengths, wind speeds and directions, temperatures of sea surface and cloud tops, polar ice, and atmospheric water-vapor content."[258] The principal reconnaissance satellite is France's Satellite Pour l'Observation de la Terre, or SPOT. First launched from French Guiana on 21 February 1986 by the Centre National d'Etudes Spatiales (CNES) into a sun-synchronous orbit of about 800 km, it is capable of producing panchromatic imagery of a 60 km wide swath of earth with resolution as small as 10 meters.[259] By comparison, SPOT's commercial competitors, the U.S. Landsat and the Soviet photos marketed by Soyuzkarta, have resolution of 30 meters and 5 meters, respectively.[260] Photos taken by SPOT, which can be stored on tape or transmitted to ground stations immediately, have been marketed commercially by Spot Image Corportation, notably showing the Soviet nuclear power plant at Chernobyl following its explosion in 1986, the Silkworm missile launch sites on the Persian Gulf, and the Soviet phased-array radar near Krasnoyarsk.[261] Two more SPOT spacecraft are scheduled to be launched by 1991, followed by two additional improved versions, offering resolution of 1-3 meters, by 1995.[262] Sales of SPOT photographs has become a booming business. Revenues in the last quarter of 1990 exceeded those from all of 1989, and SPOT executives were forecasting a 30% growth rate for 1991.[263]

Europe is beginning to consider developing the ability to conduct manned flight, but presently relies primarily on collaboration with the United States. It has participated with NASA with Spacelab, which flew on four shuttle flights during the 1980s and is scheduled for an additional fourteen by 1993. Europe is also participating in NASA's development of a manned space station through a three-part program collectively called Columbus. It includes a variant of the unmanned SPOT known as the Columbus Polar Platform; the Columbus Man-Tended Free-Flyer, which is to fly alongside the space station Freedom; and the Attached Pressurized Module, which is one of four making up the space station itself.[264] Europe is also steadily working toward the ability to independently conduct manned flight by the development of the space plane Hermes, a $4.5 billion program funded primarily by France, Germany and Italy, which is tentatively scheduled to fly in 1998, and by the subsequent development of a fully reusable two-stage shuttle known as Saenger.[265]

Generally, military activities are largely absent from European space programs, although as noted above Great Britain currently uses military communications satellites, and Italy and Spain are planning to employ them. Great Britain is also currently investigating the feasibility of developing LIGHTSATs, much like the United States, which could be launched as secondary payloads on the Ariane for the UK Ministry of Defense.[266] France in 1985 established a space staff to establish priorities, programs and organizations which will enable the nation better to employ its nuclear deterrent and to handle crisis management. Subsequently, France's main emphasis has been to develop a military satellite communications system, work toward the launch of the Hermes space plane in 1998, and reduce its dependence for space support on the United States.[267] France's intelligence service has also shown a tendency to draw information from SPOT, and is expected to continue to do so until a French military reconnaissance satellite, called Helios, is launched in the mid-1990s.[268]

Non-European Space Activities

A handful of non-European nations, or European nations acting independently of the ESA, have launched small satellites of their own; still others have had satellites launched for them by other nations. Non-European nations with launch capabilities currently include Japan, China, India and Israel; sometimes Australia, France, Italy and Great Britain are also considered launching nations.[269] Others which may soon possess such technology include Brazil, South Korea and Taiwan.[270] Iraq was also listed with this group until the Gulf War occurred. It has been estimated by the Central Intelligence Agency and the Defense Department that up to twenty nations, to include hostile states such as Iran and Libya, could possess ballistic missiles and the ability to employ them by the year 2000.[271] Iraq, for instance, tested a three-stage rocket on 5 December 1989 which is credited with the capability to launch satellites, although the test is generally believed to have been of an ICBM prototype.[272]

The capabilities of the nations which possess actual launching capabilities currently vary widely. Many have become interested in reconnaissance satellites since the commercial success of France's SPOT; Japan, India and Israel have all launched photo-reconnaissance satellites since 1987.[273] China, Japan, India and Israel already have proven launch vehicles. China first attempted to get into the commercial launching business with its Long March 2 in 1985. French and German satellites were successfully launched by the Long March 2 in 1987 and 1988, respectively.[274] Although it has not been very successful thus far because of technology transfer restrictions which prevent the shipment of Western payload to the launch site, it has contracted to launch a Swedish satellite in 1991, and two Australian satellites in 1992. Additionally, a very limited agreement was reached between China and the U.S. in November 1988 permitting launches of some U.S. payloads.[275]

China successfully launched its first satellite in 1970, and since then has placed a total of 24 into orbit. Most of these appear to be reconnaissance or communications satellites, although a small number have been tentatively identified as scientific experiments. Recent launches have included weather satellites and land remote sensing satellites. Most launches of Chinese rockets are from one of three operational launch sites situated throughout the country. Generally, the Long March 2 is launched at Shuang Cheng-tzu, in the northern part of the country, while its successor, the Long March 3 flies from Xichang, in southeastern China. A third launch facility, using the newest rocket, the Long March 4, was opened in 1988 at Taiyuan in northeast China.[276]

India had its first satellite launched on a Soviet rocket in 1975. It successfully launched a satellite using its own booster, the SLV-3, on 18 July 1980 from the national launch site at Sriharikota in the Bay of Bengal. Since then, only one other successful launch has been carried out. Despite problems with developing an independent, reliable launch capability, Indian satellites are routinely orbited by the U.S. and Arianespace. Most of these satellites are designed for communications and meteorology, although it is thought that the satellites launched independently were designed for military reconnaissance.[277]

Japan has developed a very ambitious space program which incorporates a mixture of U.S. and Japanese technology, and which includes future plans for manned flight on both U.S. and Japanese space vehicles. It became a space launching nation in 1970, and since then has conducted a total of 39 launches. Currently, most Japanese efforts are devoted to space technology itself, as opposed to launching capabilities. Japanese satellites are designed for communications, meteorology and scientific experiments. The communications satellites are felt to offer significant competition for U.S. products. The CS 2A and CS 2B, launched in 1977 and 1983, respectively, offer EHF communications which are thought to be the wave of the future. Complicating the matter is the restriction by the Japanese government on Japanese companies purchasing communications satellites from foreign sources, a problem which has caused a strain in U.S.-Japanese trade relations. Although Japan possesses a functional launch vehicle, its H-1, which is capable of placing a 1300 pound payload into GEO, it is restricted from launching foreign satellites because of a 1969 space cooperation agreement with the United States. This agreement provided Japan with U.S. launch technology, but prohibited it from transferring that technology to third parties and from launching their satellites without U.S. consent. Consequently, Japan for the moment is willing to compete on the basis of satellites only. It is, however, developing a new launcher, the H-2, which will be built entirely by Japan and be capable of lifting a two ton payload to GEO. This rocket is intended to be launched in 1993 and should bring Japan into commercial competition with both the U.S. and Arianespace. Japan currently operates two launch facilities on islands in the Pacific, one at Uchinoura and the other at Tanegashima, both approximately 900 km southwest of Tokyo.[278]

Israel became the newest space launching nation on 19 September 1988 when it placed Horizon 1 into orbit. This satellite was only designed for a short operational life, and it has since come out of orbit. It is believed that it was a test in the development of a military reconnaissance capability. Not much information is known of the launch site or the launch vehicle. It is thought that the rocket was launched from a facility either on the Mediterranean coast south of Tel Aviv, or from the Negev Desert. The booster is reportedly a derivative of the Jericho II missile. Israel has announced plans to orbit a second and third satellite by 1992.[279]

Launch sites are somewhat of a problem for non-European nations. Generally, because of geographical constraints they are restricted in the types of launches which may be conducted. For example, Israel must launch westward over the Mediterranean, against the earth's rotation, because of the obvious political problems with launching to the east; Japan similarly has constraints over launching to the east because of the objections of its very powerful fisherman's lobby.[280] As a solution, the Australian government has proposed to build a spaceport on the north tip of Queensland, at Cape York, which would serve as a neutral, multi-national launch site free of any technology transfer problems. Already Australia has contracted with the Soviet Union for the use of its Zenit launch vehicle, with which it could commercially launch satellites for a cost which is $15 million less than U.S. commercial launchers.[281] It would have the additional advantage of being nearly as close to the equator as the Ariane launch site at Kourou in French Guiana, which significantly reduces the costs to place a satellite into GEO.[282]

Space technology has become inextricably connected with life in the modern world. This potential of space to affect our lives is both a blessing and a curse, however, for although it certainly makes life easier, it can also significantly enhance the military power of any nation which effectively utilizes it. This chapter has described America's space organizations, and has discussed some of the current applications of space technology by the U.S. military and some of the military space systems which are under development. It has also discussed the space programs of America's potential adversaries and competitors, with an eye toward their capabilities and the threat they might pose to the United States. The next chapter, "The Army's Warfighting Doctrine," will describe how the Army intends to fight its future wars, and will seek to provide the basis for answering the questions of whether that doctrine is dependent on space assets for its execution, and to what degree it can be made more effective by incorporating space assets into its operations. Ideally, the doctrine will consciously utilize the potential of space described here to enhance the Army's effectiveness on the battlefield and improve its chances for success.

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CHAPTER 4

THE ARMY'S WARFIGHTING DOCTRINE

> Doctrine must at least keep pace with the changing technology of war; ideally, it should anticipate technological change.
>
> Colonel Huba Wass de Czege, 1982

> Our doctrine is to fight one synchronized battle on all areas of the battlefield.
>
> General Maxwell R. Thurman, 1988

The development of the Army's warfighting doctrine is an evolutionary process. Doctrine writers attempt to look some 15 to 30 years into the future, determine what the world will look like then in terms of U.S. interests and the threat to those interests, and design a method of waging war which is capable of protecting those interests and defeating the threat. Ideally, the doctrine which is written should lead to technologies which make it feasible, although usually it seems that things go the other way around.

Since 1982, the Army's warfighting doctrine has been AirLand Battle. It evolved from a doctrine called the Active Defense, and will in turn lead to doctrines now being developed called AirLand Battle Future and Army 21. These are intended to be implemented in about 15 and 30 years, respectively. Each of them is naturally at a different level of development, with AirLand Battle being fully developed and implemented, while Army 21 may be charitably described as hazy at best.

This chapter discusses the key principles involved in AirLand Battle and AirLand Battle Future. It is intended to provide the reader with a basic understanding of how the Army plans to fight its wars, both now and for the next several decades. It does not highlight the degree to which space is incorporated in the doctrines. This will be brought out in Chapter 6. Army 21 is not discussed here due to its current tentative nature.

AIRLAND BATTLE DOCTRINE

The Army's present warfighting doctrine is known as AirLand Battle (ALB). In the words of FM 100-5, Operations, its name comes from a recognition "of the inherently three-dimensional nature of modern warfare. All ground actions above the level of the smallest engagements will be strongly affected by the supporting air operations of one or both combatants."[1]

AirLand Battle is a concept which developed under the guidance and direction of Generals William E. Dupuy and Donn Starry, successive commanders of the Army's Training and Doctrine Command (TRADOC) in the late 1970s and early 1980s. It was first publicly promulgated as Army doctrine by General

Starry in his Kermit Roosevelt lecture series of 1982.[2] It had been developing as a doctrine for several years, instigated in part by the ferocity and lethality demonstrated in the 1973 Arab-Israeli War.[3] A comprehensive discussion of this development is to be found in a thesis submitted to Princeton University by Aaron Blumenfeld in 1989 entitled <u>AirLand Battle Doctrine: Evolution or Revolution?</u>.

AirLand Battle views war as occurring on three levels. The first, Military Strategy, is "the art and science of employing the armed forces of a nation or alliance to secure policy objectives by the application or threat of force."[4] Strategy is the global view, dealing with how the resources of the nation are allocated throughout the world, and establishing the conditions by which force is used. Military Strategy is typically considered to be the province of the nation's senior military leadership, the Joint Chiefs of Staff, and to a lesser degree, of the combatant CINCs.

The second level of war, called Operational Art, is "the employment of military forces to attain strategic goals in a . . . theater of operations through the design, organization, and conduct of campaigns and major operations."[5] It involves the design of a series of actions orchestrated to attain a particular strategic objective within the theater of operations. The Operational commander sets the goals for the military forces of a theater of operations and plans how and when to use those forces to attain the goals. He accomplishes this by determining the enemy's source of strength or balance, his 'Center of Gravity,' and then concentrating all available combat power against that point. Typically, a corps is considered the lowest operational echelon of command.

The third level of war is Tactics. Tactics is "the art by which corps and smaller unit commanders translate potential combat power into victorious battles and engagements."[6] Successful tactical commanders win battles by maneuvering their force to a position on the battlefield in which it possesses an advantage over the enemy, then using firepower to exploit that advantage.

AirLand Battle doctrine today continues to embrace the basic concepts as described by General Starry in 1982. It guides operations at the operational and tactical levels of war; it is essentially the method by which strategy is implemented. It is a fire supported, maneuver based doctrine which emphatically emphasizes the offensive. As such, it describes the Army's approach for generating and applying the full range of combat power at the tactical and operational levels.[7] It is characterized by an extended battlefield which requires different types and mixes of systems. It assumes the necessity of joint operations between elements of the Army, Air Force, and at appropriate times, the Navy. A key concept of this doctrine is the notion that the Army cannot win its fight without assistance from its sister services, the Air Force, Navy and Marines,[8] and vice versa. As an example, the Air Force provides the Army with assistance in the form of Close Air Support, Battlefield Area Interdiction, Airlift, Electronic Warfare, and Counter-Air; the Army in turn provides the Air Force with assistance in the form of Fire Support for the Suppression of Enemy Air Defenses, Air Defense, and Target Intelligence and Acquisition.[9] The battlefield on which ALB is played out is traditionally linear with an emphasis on controlling the flow of forces into the close battle area.[10]

The corps commander is the primary player in AirLand Battle, for it is he who is first able to combine maneuver tactics with operational fires. The goal of this operational level commander is to seize the initiative, thereby creating opportunities for maneuver which result in the defeat of the enemy force. The operation he conducts involves not only the traditional battle between maneuver units, but also deep operations designed to control the flow of follow-on forces into the battlefield, thus permitting the maneuver force to defeat one echelon of the enemy's forces before they can be reinforced by a succeeding wave. Each of these efforts are conducted simultaneously. The AirLand Battle commander in the field is required to direct maneuver units in the close, tactical battle to defeat the first echelon while employing deep, operational fires to disrupt and delay the follow-on echelons.

AirLand Battle doctrine is notably different from its immediate predecessors in three respects. First, unlike the various form of the defense to which the Army subscribed previously, AirLand Battle is explicitly an offensive doctrine. It seeks to take the fight to the enemy, seizing the initiative and setting the terms for the battle. Although defensive operations at times will certainly be necessary, the doctrine prescribes a defense which is in reality a combination of the offensive and the defensive, part static and part dynamic. Second, it depends heavily on the deep attack, engaging enemy forces at great distances from the line of contact, and attriting and disrupting their formations before they arrive in the battle area. This 'extended battlefield' requires fire support systems capable of delivering accurate, long-range fires, reliable and timely intelligence on the enemy situation, and close cooperation between ground and air forces. Finally, it emphasizes the decisiveness of maneuver in battle rather than relying exclusively on overwhelming firepower for success. Recognizing that the United States will most likely not possess numerical superiority in future conflicts, and may not possess the qualitative superiority required to stand and strike blow for blow, it dictates that U.S. forces will have to maneuver to mass and attack the enemy's formations at their weakest points.

AirLand Battle is based on the nine Principles of War accepted by the U.S. Army. These nine provide unchanging general guidance for the conduct of warfare. It also emphasizes the concept of a Center of Gravity, that point of enemy vulnerability against which combat power must be brought to bear if success is to be achieved. The conduct of the battle must be well thought out and directed against the enemy's Center of Gravity; mindless attrition is to be avoided.[11] These concepts lead to four principles which are central to the operational concept of AirLand Battle doctrine. These principles are:

- the primary objective of all operations is to destroy enemy forces.

- the importance of seizing and keeping the intiative is crucial to success in combat operations.

- the intent of each higher commander must be understood by the entire chain of command.

- the tenets of initiative, depth, agility and synchronization are important for success.[12]

These last-named tenets define the characteristics of successful operations. The ability to fight in accordance with these four will determine how successful the Army is on the battlefield.[13]

Initiative is the key to success in AirLand Battle. It means setting the terms of the battle through action, and implies the need for an offensive spirit throughout all operations. It imposes our will on him. The U.S. commander endeavors to seize the initiative by striking from unexpected directions and aggressively continuing operations so as to maintain constant pressure on the enemy and prevent him from recovering from our attack. Seizing the initiative is essential if the enemy is to fight on our terms, but it can only be seized by leaders who are willing to act independently and who are willing to accept some risk. Consequently, AirLand Battle relies heavily on the active leadership of its junior commanders. In order to allow junior leaders to do this, the commander must ensure that his idea of how the battle should be fought is clearly communicated to his subordinates. Decision authority must then be decentralized to the lowest practical level to overcome inertia and speed up action by allowing the subordinates to act within the specified guidelines of the commander's intent.[14] All junior leaders are expected to understand the higher commander's intent for winning the battle, and to tailor their plans and conduct their operations in accordance with that intent, even in the absence of additional instructions during the actual fight.[15]

Agility is the ability of the friendly force to react more quickly than the enemy to the events of the battle. It gives the friendly commander the ability to seize the Initiative. In the battle, Agility is reflected in the ability of the commander to concentrate his forces at a decisive point, then shift them rapidly to another as the battle progresses, thereby keeping the enemy off-balance and forcing him to fight on our terms. Agility is not merely a nimbleness of units, however, but also a nimbleness of the thinking of leaders. To be mentally agile, the leaders must continuously endeavor to 'see' the battlefield, sorting fact from mirage, so that they can make a correct decision and act effectively.[16]

Depth is the extension of the battlefield in space, time and resources. Effective use of depth gives the commander the ability to plan effectively for future actions, allowing himself time and room for maneuver and time to gather the necessary resources. If the commander plans and executes in depth, his attack will have the necessary momentum to carry it through to its objective. If the commander plans and executes in depth, his defense will be able to absorb the enemy's strike and then turn it around to permit us to seize the initiative. In all operations, commanders must endeavor to 'see' deep into the enemy's rear and attack his forces throughout the battlefield.[17]

Synchronization of fighting systems is essential to successful execution of AirLand Battle doctrine. To do this well, the commander must be able to 'see' the battlefield, visualizing via all available sensors not only the terrain on which the battle will be fought, but also where his units and those of his enemy are located. He must do this better and more quickly than his opponent. He must also be a master tactician, able to effectively mentally translate in terms of speed, space and time when looking at the battlefield. He must endeavor to employ all of his fighting assets, ensuring that as many weapons systems as possible are brought into the fight. Finally, he must thoroughly understand Army systems and how they must all be integrated together effectively to ensure a successful fight.[18]

As mentioned above, AirLand Battle is a recognition on the part of the U.S. Army that it probably will be required to fight outnumbered in its next major conflict. The doctrine compensates for this resource inferiority by applying our specific strengths against our enemy's specific vulnerabilities. It does not envision a head-on fight; indeed, the doctrine recognizes that attrition warfare is a viable option only for the resource superior side. It plans to compensate for any numerical inferiority through superior planning and execution, fighting in accordance with the four tenets of AirLand Battle to strike decisively at the enemy's Center of Gravity.[19] Consequently, the foundations for this doctrine are the imperative to retain a clear tactical advantage, to fight at the operational level, compel asymmetric force exchange advantages, to maintain superior force agility, and to ensure a linkage between the strategic, operational and tactical levels of the war.[20]

AirLand Battle is essentially conducted as one battle in three parts. What we have come to traditionally think of as the battlefield is called the Close Battle. This is the basically linear fight in which the maneuver elements of each army engage each other at relatively short range. Operations in the Close Battle bear the ultimate burden of victory or defeat. Forward of that fight is the Deep Battle. This is the fight in which the friendly commander engages the enemy's follow-on forces with operational fires in order to attrit them and delay the tempo of their arrival into the Close Battle, prevent them from massing for a breakthrough or counter-attack, and to disrupt their logistical support. The commander's goal really is to degrade the freedom of action of the enemy commander and establish the tempo of the battle. Successful operations in the Deep Battle create the conditions for future victory in the Close Battle. To the rear of the Close Battle is the Rear Battle. This is the fight in which the friendly commander protects his command and control, fire support and logistical elements from enemy operational attack by maneuver units and/or special operating forces. At stake is his ability to assemble and move reserves, redeploy fire support assets, maintain and protect the sustainment effort, and provide effective command and control throughout the battlefield. Although operations in the Rear Battle may have little immediate impact on the Close Battle, they are essential to subsequent operations.[21]

Because the Deep Battle creates the conditions for victory, its operations underlie all activities throughout AirLand Battle. Such Deep Operations, which include deep fires, long-range surveillance and special operations, allow the friendly commander to shift from the defensive to offensive operations and seize the initiative from his opponent, to prevent the enemy from massing, and to create 'windows of opportunity' for friendly offensive action.[22] When conducting

Deep Operations, the corps commander is the principal orchestrator of all friendly combat actions, and he carries out his actions so as to bring the most power possible to bear on the enemy throughout the depth and breadth of the battlefield. At the Operational level, he conducts his deep operations so as to isolate the current battles in the Close Area from further enemy support or reinforcement, with an eye toward influencing the conduct of future close battles. Typically these operations will occur to a depth of about 100 kilometers. At the Tactical level, he does so to shape the battlefield to his advantage, forcing the enemy to fight the Close Battle on our terms. The principle objectives of these deep operations are to limit the enemy's freedom of action, alter the pace of operations in our favor, and to isolate the close fight on advantageous terms.[23] The primary strike assets for the deep battle are presently air and artillery interdiction, although it also involves the use of offensive electronic warfare, deception and operational maneuver.[24]

Much of AirLand Battle doctrine seems to have been vindicated during the recent Gulf War. CENTCOM's conduct of the campaign was a demonstration in agility, initiative, the use of depth throughout the theater, and the synchronization of all combat forces available to the commander. It relied on the speed of the attack and an offensive spirit to quickly eliminate the combat power of the enemy force, and performed operations in deep, close and rear areas. It seems inevitable that that campaign will become the textbook example of how to properly execute AirLand Battle doctrine, and will illustrate what results can be achieved if it is executed properly.

The successful AirLand Battle commander will have to be effective at command and control on a confused, fast-paced battlefield, and will have to be a master at synchronizing all of his unit's activities in the close, deep and rear battles. He will have to be able to think forward in both space and time, and will have to get his subordinates to think in step with him. Every element of his command will have to be enfused with the 'offensive' spirit, no matter what its mission. Without these abilities, AirLand Battle will never be executed effectively. Difficult as this may seem, these requirements will only become more stringent as doctrine gradually evolves over the coming decade into what is now called AirLand Battle Future.

AIRLAND BATTLE FUTURE

AirLand Battle Future (ALB-F) is the Army's next iteration of its warfighting doctrine. It is intended to become operational about the turn of the century. It is considered to be an evolutionary outgrowth of the present AirLand Battle doctrine, and will be used to describe the required capabilities and force structure of the Army 10-15 years from now.[25] Because of its evolutionary nature, the four tenets of AirLand Battle doctrine, Initiative, Agility, Depth, and Synchronization, will remain the keys to conducting combat operations using AirLand Battle Future.[26]

ALB Future is driven by certain current trends. For example, the cost, complexity, range, lethality, accuracy and sensor capability of weapons systems will all improve over the next two decades; yet the numbers of weapons systems which the U.S. will actually employ on the battlefield of the future will decrease, principally due to fiscal constraints. Similarly, the actual number of units, and hence their density on the ground, will decrease in the future. The likelihood of nuclear or global high-intensity conflict will decrease in the future; but the likelihood of regional and low-intensity conflicts will increase. Finally, both budget authorizations and the size of the military manpower pool will decrease over the next two decades. Taken together, these trends lead to certain conclusions which dictate a new set of concepts by which the U.S. Army will wage war in the future.[27]

Some of these concepts are the following. The Army will have to develop a greatly expanded ability to 'see' the battlefield; it will have to use sensors more than soldiers to locate, track and acquire enemy targets. It will have to attack enemy formations by fire and by rapidly moving combined arms teams. This attack technique will require improved command and control and data distribution systems. A clear link between sensors, attack forces and rapidly moving reconnaissance forces must be established. The battlefield commander will have to work even harder to seize the initiative and set his own tempo for the battle.[28]

The implications of these future trends are significant. The reduced number of forces and consequent lower battlefield density indicates that future warfare will tend to be non-linear and characteristically fought by highly mobile forces. This tendency will be most apparent at the operational level, although it will often be evident at the tactical level as well. A non-linear battlefield of this sort will require the development of mission tactics and extreme decentralization of decision authority. The increase in mobility will require more agile, mobile force structures and unit organizations which can be tailored to specific battlefield situations. The tendency toward regional and low-intensity conflicts also points toward non-linear warfare and the requirement for force structures which may be easily tailored. The changes in weapons systems will put a premium on tactics which employ long-range precision munitions. Such weapons, though, will require improved intelligence and target acquisition capabilities. Because of their reduced numbers, such weapons will also have to be extraordinarily reliable. The reduction in budget authority and the military manpower pool will dictate a smaller Army; hence, its organizational structure must be highly flexible to meet a wide variety of contingencies.[29]

Some features of ALB Future will probably include a regional-based strategy, a shift from a forward deployed focus to a greater reliance on contingency forces, the selective use of forward deployed forces which are optimized to mission and region, and a greater emphasis on non-combat missions to project U.S. influence and support national strategy. The shift away from forward deployed forces already has begun to happen. ALB Future will extend the depth of close operations and use that depth to vary the time, place and form of attack. The attacks themselves will be characterized by a near simultaneous decisive engagement of all enemy forces.[30]

Generally, five types of forces are thought to be necessary for AirLand Battle Future. These are: Forward Deployed, Contingency, Reinforcing, Nation Development, and Unique Mission.[31] The doctrine currently envisions a greater reliance on globally deployable contingency forces vis a vis forward deployed forces. These contingency forces will be structured so as to be rapidly tailorable to fit changing situations. Those forward deployed forces which do remain in the force structure will be optimized to region and mission. The organization of all forces will shift from the current heavy/light unit mix to a more flexible combination of active and reserve elements. In all instances, there will be a greater emphasis placed on Army noncombat missions, such as nation development, to project U.S. influence worldwide.[32]

Forward Deployed Forces will typically be maintained in those regions deemed to be of more strategic importance to the United States than others. These forces will be designed to deter the regional threat and provide visible evidence of U.S. determination to support those regions.[33]

Contingency Forces will constitute the U.S. CONUS-based strategic reserves, capable of deploying rapidly to those regions where U.S. interests are threatened. Usually this will be to an area in which Forward Deployed Forces are not present. These forces will be tailored to fit the specific mission, with the goal being to give them enough force to 'tip the scale' in the region in which they are employed.[34] Recent statements by the Chairman of the Joint Chiefs of Staff seem to indicate that these contingency forces will be composed of light, airborne, and mobile heavy forces, along with a tailored mix of forces from the other services which are capable of being rapidly deployed around the world.[35]

Reinforcing Forces are those CONUS-based forces designated to deploy in support of Forward Deployed Forces. Current thought is that these forces will be Atlantic and Pacific oriented, much like the Navy. Generally, they will have the same capabilities as Contingency Forces, but will be employed in a region which already has established command and control, intelligence, and logistical infrastructures. Typically, they will be earmarked for specific reinforcing missions and will be trained accordingly.[36]

Nation Development Forces are designed to support actions led by non-military U.S. agencies. Their purpose is to facilitate regional balance and enhance security for U.S. supported nations by building viable political, economic, military, and social institutions in the society, thereby eliminating the underlying causes of conflict. The force itself will be tailored to the specific mission, and may be composed of elements of infantry, engineer, medical, special forces, or civil affairs units.[37]

Unique Mission Forces are designed for use by the NCA across the entire spectrum of conflict with the purpose of complementing regional combat and non-combat operations with discriminative and limited-focus missions. Some of these missions might include a Command, Control, Communications and Intelligence (C3I) infrastructure operation, unconventional warfare, anti-terrorism and anti-drug operations. Typically, the force of choice for these missions will be Special Operations Forces (SOF).[38]

The greatest difference between our present doctrine and ALB Future is the emergence of the non-linear battlefield. TRADOC Commander General John W. Foss has said that non-linearity is a condition of the battlefield due to the fewer number of forces actually present, while non-linear warfare is a method of fighting.[39] The non-linear battlefield is one on which the commander, either by choice or because of a shortage of forces, has placed his units in dispersed, unconnected locations from which he can rapidly maneuver to converge on and destroy a hostile force.[40] This type of battlefield is certain to be more dangerous at the operational level, and more difficult at the tactical level, because it will require that we become better at 'finding, fixing, and fighting' than we are now.[41] This means that we will have to rely heavily on improved sensors for earlier and more accurate identification, tracking and targeting of enemy forces. The fewer forces operating on the battlefield will mean large gaps in the line, necessitating less dependence on terrain when compared with current doctrine. The battle itself will concentrate on the destruction of the enemy force rather than the retention of terrain, and will be characterized by rapid, fluid action requiring quick decisions at the lowest levels of command.[42] It must be noted that this concept of a non-linear battlefield does not preclude linear operations. Indeed, it recognizes that linear operations will at times be militarily or politically necessary, particularly at the tactical level. It does, however, seek to operate in a non-linear manner as often and at as many echelons as possible to keep the initiative and set the pace for the battle.

ALB Future envisions a battlefield of three parts: a Logistics and Dispersal Area; a Battle Zone; and a Detection Zone. Prior to the battle, all forces will be positioned in dispersed, protected positions in the Logistics and Dispersal Area. Combat and combat support forces will be preparing for future operatons in their Dispersal Areas, while combat service support elements, such as supply, maintenance and transportation assets, will be operating from the Logistics Area. In these areas units will enhance their survivability by taking steps to actively minimize their electronic and thermal signatures.[43] The Battle Zone is the area in which the corps commander has determined he wants to engage the enemy force. It is the portion of the battlefield where the tactical battle is fought by the corps' maneuver elements. Typically, it will be about 100 km deep. The Detection Zone will extend forward from the Battle Zone for up to 400 km. It will be the area which the corps monitors, with all means of surveillance available to it, to find the enemy force, determine his size and track his movements.[44]

At all costs, an attrition battle will be avoided. To ensure that this is the case, a recurring sequence of actions will be employed by the Army during operations. This Battlefield Cycle, much like the Air Force view of how to fight, is:

Disperse-Mass-Fight-Redisperse-Reconstitute

This sequence of actions will require a rapid decision-making ability, necessitating a strong real-time command system and an extremely reliable command, control and communications system. Operations will be typically characterized as a tactical offense, an operational offensive defense, and a strategic defense.45

During the Disperse phase, forces are deployed throughout the Logistics and Dispersal Areas in concealed positions beyond the range of enemy indirect fire systems. The Detection Zone is established in this phase to develop the enemy situation. Reconnaissance forces, such as cavalry and long-range surveillance units, and target acquisition sensors, both ground and space-based, are employed for this purpose. Once the enemy force has been located in the Detection Zone by these elements, it is monitored by sensors and other surveillance assets to determine its size, speed, and direction of movement. As the enemy advances further and enters the Battle Zone, he will be initially brought under long-range fire by Air Force Battlefield Air Interdiction (BAI) and Army tactical missiles and long-range guns, then by attack helicopters, artillery and MLRS, and finally by Close Air Support (CAS); simultaneously, friendly maneuver units will begin to move on multiple routes from their concealed locations in the Dispersal Area to Mass in the Battle Zone.

At the appropriate time, the Fight begins as the enemy force is engaged by both maneuver and fire. This battle is conducted by the corps, and may be either a traditionally linear fight or one which is non-linear at all echelons. The battle is usually conducted to destroy the enemy force, not to retain any specific terrain. It is characterized by the synchronized efforts of air and ground fire and maneuver elements. When the battle is complete, the maneuver forces Redisperse to prevent acquisition and destruction by the enemy. They may move to their original dispersal areas, move forward, or disperse laterally.[46] Reconnaissance forces reestablish a new Detection Zone and prepare for the next battle. The fire and maneuver elements Reconstitute their combat power with supplies moved from the Logistics Area as they await a new mission.[47]

As in ALB, the corps commander is the orchestrator. He will use reconnaissance and surveillance assets from the national to tactical levels to locate, track and acquire the enemy.[48] Using this information he will decide how to fight the enemy and how to rapidly task organize his maneuver and combat support units for that fight. Generally, he will commit his maneuver forces only if necessary; ideally, he will seek to disrupt, delay and destroy the enemy force with his long-range fires.[49] It is recognized, though, that fires are not decisive in and of themselves, and that what the deep fires actually accomplish is to establish the conditions for successful maneuver.[50] The divisions of the corps will be responsible for the conduct of the close maneuver battle. All possible measures will be taken by the division to avoid meeting engagements and to prevent the enemy from occupying hasty defensive positions; the goal is to bring the close battle to a quick, decisive and successful conclusion.[51]

For the moment, the general thoughts of what the basic force structure of the Army will be are fairly firm. In general, the force structure will emphasize smaller, more compact, deployable units which must be highly maneuverable on the battlefield and extremely lethal in order to mass and destroy the opposing force. They will also have to be more self-sufficient so that they are not tied to relatively immobile logistics systems for sustainment.[52]

To do this, the corps will remain the centerpiece of the doctrine, but it will take on a greater share of the logistical burden than it does under the present ALB doctrine. To improve the agility of the division, most Combat Service

Support (CSS) assets will be moved from the division base to the corps, thereby making the division a more mobile organization. Additionally, long-range shooters, such as MLRS, ATACMS, and attack helicopters, will be concentrated at corps.[53]

The division will be organized with smaller maneuver elements, generally on a triangular basis. The brigades within the divisions which will execute the doctrine will be combined-arms organizations, capable of tailoring to specific situations, but generally more generic than the armor, mechanized or light brigades of the present force. The division will be the command echelon to provide direct command, control, coordination, communications and reconnaissance for the maneuver elements. These maneuver elements will be backed up by a simplified service oriented logistic system, concentrated in the Corps Support Command (COSCOM) and the Forward Support Battalion (FSB), and orchestrated by the corps.[54]

Several things are necessary if ALB Future is to be successful. It is imperative that the Army develop tailorable, interchangeable forces which have high tactical and strategic mobility, and that these maneuver forces be supported by long-range intelligence, communications and fire support.[55] These forces must be capable of moving rapidly over long distances and transitioning quickly to the attack, while being provided with accurate and timely intelligence and target acquistion data. Air superiority to facilitate deep operations will be essential to success, as will the use of agile reconnaissance forces and sensors.[56]

Additionally, several strategic imperatives which prescribe key operating requirements have been identified as essential to the success of AirLand Battle Future doctrine. These are deployability, tailorable forces, global intelligence, command and control, long-range fires, manpower enhancements, and refinement of non-combat roles.[57] Deployable forces and the lift capacity to move them are required due to the shift in emphasis from Forward Deployed to Contingency and Reinforcing Forces. Fire support systems capable of delivering deep, accurate, timely and lethal fires on enemy forces will help seize the initiative on the battlefield. Reduced manpower levels in the Army will dictate the development of survivable systems with extremely high hit and kill probabilities. The use of the military in non-combat roles will require the development and training of new types of forces.

Global intelligence, command and control, and tailorable forces are probably the most important to the success of the doctrine. With a reduced force with which to respond to an increasingly volatile world, the ability to tailor units rapidly and effectively for employment in a specific region will be essential. If this cannot be done, then a much larger force structure will be necessary if the U.S. is to maintain its role of leadership in the world. Command and control, and the communications systems which make it possible, will become much more essential on the non-linear battlefield as forces in dispersed locations are maneuvered according to a synchronized plan to mass and destroy the enemy force. The ability to communicate effectively requires the use of survivable, reliable C2 systems if all forces on the battlefield are to be synchronized. Finally, the ability to detect enemy forces early so that they can be engaged by deep fires prior to maneuvering against them makes the availability of reliable and timely intelligence indispensable.[58]

The AirLand Battle Future concept assumes that certain technologies will be utilized by the military. Notable among these technologies are precise navigational aids for position locating of units and soldiers; extended range fire support systems which can hit selected targets at distances up to 200 km;

directed energy and hyper-velocity kinetic energy weapons systems which will provide effective means of destroying enemy forces while reducing required logistic support and ammunition expeditures; distributed command, control and communications networks; improved surveillance sensing capabilities which will provide all-weather, 24 hour, worldwide, realtime intelligence; and anti-missile defense systems.[59]

Ultimately, AirLand Battle Future will evolve into what is currently being called Army 21. Army 21 is a direct evolutionary outgrowth of the AirLand Battle doctrines which seeks to incorporate future technological capabilities into the Army's warfighting system. The Army 21 concept envisions much of the same conditions as AirLand Battle Future. Units will operate on a non-linear battlefield, often in the enemy's rear areas. Friendly operations will be cyclic, moving through the following phases: Move to Ready Position; Scan; Swarm; Strike; Scatter & Move to Replenishment Site; Replenish. It is an extremely dynamic concept presently, changing as new ideas are surfaced. It is intended to become the Army's operational doctrine about the year 2015.[60]

Both AirLand Battle Future, and eventually Army 21, will require leaders who are well schooled in their profession and who are completely familiar with the capabilities and complexities of every piece of equipment which is employed in support of the battle. If they do not fully understand the subtleties of their doctrine, and if they overlook items of technology which can make the execution of that doctrine more effective, then they are hampering their ability to succeed even before they begin. Just as is the case with AirLand Battle today, a doctrine as complex as AirLand Battle Future will not tolerate such oversights.

The Army's warfighting doctrine as described in this chapter, in both its current and future forms, is a complex and sophisticated concept which demands effective command and control capabilities and the ability to monitor and attack the enemy at extreme ranges if it is to be executed successfully. It seems evident that the space technology discussed in Chapter 3 can enhance the field commander's ability to do this. How extensively the Army recognizes this and is acting to incorporate space in its day to day operations is the subject of Chapter 5, "Space in the Army."

NOTES

[1]Department of the Army, FM 100-5: Operations, (Washington DC: U.S. Department of the Army, May 1986), 9.

[2]From a set of unpublished briefing outlines of speeches given by GEN Maxwell R. Thurman, collected under the title "TRADOC Viewgraph Catalog," (U.S. Army Training and Doctrine Command, Ft Monroe VA, 1989).

[3]John L. Romjue, "AirLand Battle: the Historical Background," Military Review 66 (March 1986): 53.

[4]FM 100-5, 9.

[5]Ibid., 10.

[6]Ibid.

[7]Maxwell R. Thurman, "Vision and Philosophy," a collection of letters, memorandums, official statements, and outlines of speeches given by GEN Thurman, (U.S. Army Training and Doctrine Command, Ft Monroe VA, 1988), 4-6.

[8]Maxwell R. Thurman, "Warfighting for the 1990s," a transcript of speech given at the Army War College in the United Kingdom by GEN Thurman on 9 May 1988 as part of the Kermit Roosevelt Lecture Series 1988, (U.S. Army Training and Doctrine Command, Ft Monroe VA, 1988), 14.

[9]Thurman, "TRADOC Viewgraph Catalog".

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[11]Wayne M. Hall, "A Theoretical Perspective of AirLand Battle," Military Review 66 (March 1986): 36.

[12]Ibid., 34.

[13]FM 100-5, 15.

[14]Ibid.

[15]Thurman, "TRADOC Viewgraph Catalog".

[16]FM 100-5, 16.

[17]Ibid., 16, 17.

[18]Maxwell R. Thurman, "Presentation at the Army Command Academy," given in Nanjing China on 8 July 1988, from Selected Works of the Sixth Commander, United States Army Training and Doctrine Command, (U.S. Army Training and Doctrine Command, Ft Monroe VA, 1989), 99, 100.

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[20]Thurman, "Vision and Philosophy.", 4-7.

[21]FM 100-5, 19-21.

[22]Huba Wass de Czege, "The U.S. Army's Doctrinal Reforms," in AirLand Battle Doctrine, (Carlisle PA: The Art of War Colloquium at the U.S. Army War College, June 1983), 44.

[23]Thurman, "TRADOC Viewgraph Catalog".

[24]Wass de Czege, 45.

[25]From an unpublished briefing outline of a speech given by GEN John W. Foss to the Pre-Command Course at Ft Leavenworth KS on 5 October 1989, collected under title "TRADOC Briefings Book," (U.S. Army Training and Doctrine Command, Ft Monroe VA, 1990), 1.

[26]"AirLand Battle Future Umbrella Concept," Draft Copy, (Concept and Force Alternatives Directorate, Ft Leavenworth KS, n.d.), 35.

[27]John W. Foss, "A Capable Army: Today and Tomorrow," a speech presented in the United Kingdom in May 1990 as part of the Kermit Roosevelt Lecture Series 1990, (U.S. Army Training and Doctrine Command, Ft Monroe VA, 1990), 38; also Foss, "BG's Conference", 3.

[28]Foss, "Capable Army," 40-41; also Foss, "BG's Conference," 3; also Thurman, "TRADOC Viewgraph Catalog."

[29]From an unpublished briefing outline of a speech given by GEN John W. Foss to the Pre-Command Course at Ft Leavenworth KS on 30 November 1989, collected under title "TRADOC Briefings Book," (U.S. Army Training and Doctrine Command, Ft Monroe VA, 1990), 2.

[30]Foss, "Pre-Command Course 5 October 1989," 1.

[31]"AirLand Battle Future Umbrella Concept," 15.

[32]"AirLand Battle Future - the Concept," information paper located in the Combined Arms Research Library, (U.S. Army Command & General Staff College, Ft Leavenworth KS, n.d.), 2.

[33]"AirLand Battle Future Umbrella Concept," 16.

[34]Ibid.

[35]Colin L. Powell, statement before the Senate Committee on Armed Services, 21 February 1991.

[36]"AirLand Battle Future Umbrellan Concept," 17.

[37]Ibid., 17-19.

[38]Ibid., 19, 20.

[39]John W. Foss, "AirLand Battle Future," Army 41 (February 1991): 21.

[40]"ALB-F - the Concept," 4.

[41]From an unpublished briefing outline of a speech given by GEN John W. Foss to the IET Brigade Commanders' Conference at Ft Knox KY on 6 December 1989, collected under title "TRADOC Briefings Book," (U.S. Army Training and Doctrine Command, Ft Monroe VA, 1990), 4.

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[43]Stephen Silvasy Jr., "AirLand Battle Future - the Tactical Battlefield," Military Review 71 (February 1991): 3, 5.

[44]Foss, "Capable Army," 41-43.

[45]Foss, "Capable Army," 42; also Foss, "BG's Conference," 3.

[46]Silvasy, 4.

[47]"ALB-F - the Concept," 7-12.

[48]Foss, "AirLand Battle Future," 22.

[49]Foss, "Capable Army," 41-43.

[50]Foss, "AirLand Battle Future," 23.

[51]Silvasy, 7, 8.

[52]Foss, "Capable Army," 32.

[53]Foss, "AirLand Battle Future," 23.

[54]Foss, "Capable Army," 42; also Foss, "BG's Conference," 3; also Thurman, "TRADOC Viewgraph Catalog."

[55]Foss, "Pre-Command Course 5 October 1989," 1.

[56]"ALB-F - the Concept," 6.

[57]"AirLand Battle Future Umbrella Concept," 27.

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[60]Foss, "Pre-Command Course," 1.

CHAPTER 5

SPACE IN THE ARMY

> Space operations assets require full integration into the Army's arsenal.
>
> Colonel Paul A. Robblee, Jr.
> Parameters, 1988

> The Army's space concept is to use space system capabilities to enhance our ability to execute AirLand Battle doctrine in joint and combined efforts, for all levels of war, across the full spectrum of conflict.
>
> General Maxwell R. Thurman
> Fort Leavenworth, 1988

AirLand Battle doctrine guides the Army's thoughts of how to successfully wage war. Yet, although no version of that doctrine depends exclusively for its success on space, it seems likely that the potential benefits which space assets provide can enhance its effectiveness. Planners in the Army certainly recognize that fact and have created within the Army a complex infrastructure whose purpose is to ensure that the capabilities afforded by space assets, as described in Chapter 3, are effectively incorporated into the execution of AirLand Battle doctrine, as described in Chapter 4. This chapter describes that infrastructure, the logic behind it, and the means by which it envisions utilizing space technology.

Space Doctrine. There are several schools of doctrinal thought regarding the most appropriate way to employ a nation's space forces. As used here, a nation's space forces are "those governmental systems which support military functions and are designed to operate in the space environment for extended periods of time."[1] In this sense, space forces include all military components which are placed into earth orbit, whether manned or unmanned, armed or unarmed, but do not include ballistic missiles or high-flying aircraft. The doctrinal thought which has emerged is generally divided into four groups, each reflecting their determination of the value of space forces, what a war in space might entail, how space forces would be employed in a war, and what organizational structure would best facilitate that employment. These four schools are generally termed the sanctuary, survivability, control, and high-ground schools.

The sanctuary school holds that "the primary value of space forces is their capability to see within the boundaries of sovereign states, thereby reducing the ability of nations to make surprise attacks."[2] Only the legal overflight of nations permits this to occur. Such overflight capability is the only reliable means to verify arms limitations agreements between nations; consequently, to ensure that this verifying ability remains intact, space must be designated as a war-free 'sanctuary.' The school holds that if any conflict short of global nuclear war should occur, space forces will retain their value to view the enemy's territory, thus providing a damper for further escalation. If space forces are attacked to eliminate their ability to provide surveillance, however, the blinded and now mortally threatened nation might feel compelled to launch a nuclear attack. Hence, space must remain a sanctuary to prevent such a catastrophe from occuring. When utilized, space forces in the sanctuary must remain completely non-warlike to fulfill their primary purpose of surveillance. There is no value in the establishment of a national organization to orchestrate the efforts of the nation's space forces; such an organization would actually have a destabilizing effect.[3]

The survivability school holds that because space forces are constrained by physics to move in predictable orbits, they are inherently more vulnerable to attack than ground forces and are thus less valuable to national security. If one side destroys an opponent's satellite, a destructive response will not be long in coming; any advantage gained by using space forces can be easily negated. Consequently, the survivability school advocates extreme redundancy in space systems, yet is unwilling to completely rely on them for success. Because satellites are so vulnerable to attack, the school also advocates passive defense measures, such as avoiding vulnerable orbits at low altitudes or high density geosynchronous orbits, to an active defense, and prefers single-mission satellites, which can compound the opponent's targeting problem, to extremely complex, multifunctional, long duration satellites. An off-shoot of this single-mission concept which the school holds is the concept that ASAT weapons must take on an offensive role since actively defending satellites in orbit is infeasible. Organizationally, a centralized command and control element is of great advantage, because someone must be in charge to decide if it's worth it to attack an opponent in space, knowing that retaliation is sure to follow.[4]

The control school holds that the ability to effect deterrence of war on earth is enhanced by control of space. In the event of a conflict, priority must first go to achieving superiority in space, so that the benefits of space technology can then be applied to the ground battle. To achieve this superiority, access to space must be denied to the enemy, and friendly space forces must be successfully defended. Friendly forces must therefore be deployed together in orbits in which they can be easily protected, while friendly ground and space-based ASAT weapons actively seek to destroy enemy forces in space. To effect this, a central authority must have control of the space battle.[5]

The high-ground school holds that a space-based ballistic missile defense can best take advantage of the global coverage characteristic of space to achieve success. Furthermore, a space force can do this better than any other military force, and so should have preeminence among a nation's armed forces. Thus, space will become the nation's new center-of-gravity. Consequently, all warfare and its accompanying weapons systems will move out into space and away from the earth. It does envision a requirement for a central authority to control the space battle, but goes one step further than the other schools of thought to suggest a separate Space Force.[6]

In general, U.S. and Soviet space organizations in the past have tended toward the thoughts of the survivability school; recent writings, though, have begun to emphasize the importance of space control. Taking this to heart, both nations are presently involved in offensive ASAT development. Additionally, some strategists have begun to propose that the U.S. should become more concerned with the superiority demanded by the control school than with survivability, stating that "until the United States can routinely get to and from orbit when necessary, it can never protect, maintain, and replace its assets there."[7] This type of thinking appears to be more in line with the verbage of the National Space Policy, as described in Chapter 3.

Arguably, space control is becoming the dominant theme in the evolving U.S. space doctrine. Increasingly, it is believed that it is a prerequisite for the success of American ground, air and naval forces in battle.[8] To achieve effective space control, the nation must have a global space surveillance capability, and the ability to launch on call. While the first is relatively complete, the second is only wishful thinking at the moment. Space strategists continue to press their case for the development of a better U.S. launch capability.

U.S. space doctrine has fluctuated somewhat between these schools of thought over the years. In general, its present form is an amalgam of elements from each of the four schools of thought. With the advent of USSPACECOM, a framework of centralized control with decentralized execution has been established for the conduct of space operations. Generally, these space operations are held to encompass four types of military missions: space control, force application, force enhancement and space support. Space control and force application are deemed to be combat missions; force enhancement and space support are deemed to be combat support missions.[9]

Space control operations are those activities taken to ensure U.S. access to space while denying such access to hostile nations. Space control operations include both space interdiction and counterspace operations. In space interdiction, an enemy's satellite systems would be attacked either with some sort of ASAT weapons system, or by destroying their ground stations, or by disrupting their communications control links. In counterspace operations, U.S. space systems would gain control of the space medium by using either spaceborne or terrestrially-based means. USSPACECOM has elevated space control to a position of prominence, stating in its Pamphlet 2-1, Doctrine for Space Control Forces:

> The preeminence of the space control mission to space warfare cannot be overstated. U.S. combat support satellites will be impotent in war if the enemy denies their use to U.S. terrestrial combat forces. Likewise, U.S. forces must be able to deny the enemy the advantages which can be accrued by using satellites for locating and targeting U.S. and allied terrestrial forces.[10]

Force application involves those activities by which an enemy's terrestrial forces could be engaged by space-based weapons systems. It includes variations of the traditional Air Force missions of strategic bombing, battlefield area interdiction, and close air support. Currently, the ability to conduct force application operations is strictly a mental exercise.

Force enhancement includes those activities conducted from space which serve to positively influence the capabilities of friendly space or terrestrial combat forces, but do not themselves engage the hostile targets. Such activities include all the traditional functions of reconnaissance and surveillance, early warning, meteorological and earth monitoring, navigation, and communications. An important facet of force enhancement operations is the desire to reduce friendly planning and execution time to the point that it will 'turn inside' the enemy's decision and execution cycle.[11] From the Army's point of view, force enhancement is probably the most important of these four space missions.

Space support encompasses all those activities which serve to support space-based systems. It involves both ground and space platforms, and includes such activities as launch, orbit transfer and station-keeping, recovery, and management, planning and operations support.[12]

Together these four missions make up the whole of the United States' current military space doctrine.

Army Space Operations. As its portion of the plan by which USSPACECOM will implement its doctrine, the Army is assigned specific missions for space operations in JCS Pub 2, Unified Action Armed Forces. These assignments are made along the lines of the three levels of war discussed in the last chapter.

At the strategic level, the Army has responsibility to provide ballistic missile defense and conduct space control operations. As described above, space control essentially means the ability to assure U.S. freedom of action in space, and the ability to deny such freedom of action to an adversary. Such an ability requires the development of effective anti-satellite, survivability, and surveillance capabilities.[13] To accomplish this task, efforts are ongoing in the development of missile defense systems and ground-launched anti-satellite (ASAT) capabilities, and selected communications capabilities.

At the operational and tactical levels, the Army is endeavoring to develop better and more effective methods by which to employ space capabilities. As discussed in Chapter 3, these capabilities now include communications satellites which are hardened to nuclear electromagnetic pulse damage and are highly resistant to jamming and interception; reconnaissance, surveillance and target acquisition (RSTA) satellites which can provide worldwide, real-time, all weather intelligence 24 hours a day; weather satellites for monitoring weather patterns and improving the ability to forecast future weather activities; earth monitoring satellites which can provide terrain information of anywhere in the world for use in the creation of standard maps or three-dimensional databases for use in simulators; and navigation satellites which can provide ground units with position data accurate to within 10 meters. Ideally, these systems combine to enhance the field commander's capability in the execution of AirLand Battle.[14] How well that is actually being done will be discussed in Chapter 6.

The Army's method for developing the ability to conduct its assigned space missions is outlined primarily in two documents, the Army Space Master Plan (ASMP) and the Army Space Architecture. The purpose of the ASMP is to implement the Army Space Policy by establishing the Army space program.[15] The Army Space Policy has three basic provisions:

> 1). Exploit space activities that contribute to the successful execution of Army missions.
>
> 2). Support assured access to space and the use of space capabilities to enhance the accomplishment of strategic, operational, and tactical missions.
>
> 3). Develop a pool of Army space expertise for judicious planning, to include development of concepts, requirements, and a long-term management strategy.[16]

Signed by the Chief of Staff of the Army in April 1987, the ASMP provides the strategy, guidance and taskings to develop and institutionalize the Army's space program. It is the document which guides the selection of systems which will contribute to the successful development of the Army's space program. As such, its provisions are integrated into all Army near, mid, and far-term planning and budgeting documents.[17]

The Army Space Architecture is the heart of the ASMP. It is an integrated 'blueprint' for planning and executing doctrine, for training, and for organizational and materiel development.[18] Its purpose is to ensure that appropriate space solutions are found for applicable battlefield problems. It specifically is the document which determines how space capabilities can be used to support the AirLand Battle commander. It establishes priorities for the development and improvement of these space capabilities. The architecture addresses the five areas of space use highlighted in Chapter 3 (i.e.

Communications, Navigation, RSTA, Weather, and Geodesy), plus four others: Fire Support, Aerospace Control, Strategic Defense, and Military Man in Space (MMIS). The Army Space Architecture is typically updated annually by TRADOC; it was most recently updated in October 1990.[19]

A third document, developed and promulgated by USCINCSPACE, also guides the Army's space efforts. This document, the Assured Mission Support Space Architecture (AMSSA), is a joint effort to develop a long term space architecture. It is intended to determine solutions to identified deficiencies in the U.S. space program, particularly in the areas of combatant force requirements for space support. It looks forward through the next thirty years at the threat, at projected technological developments, and at anticipated requirements to determine a joint, fully integrated network of space systems designed to support all U.S. space efforts. The AMSSA process is the principal means by which the Army ensures that its requirements for space are clearly identified and continuously updated.[20]

Army Organization for Space. The Army has a large number of organizations which oversee selected portions of its space effort. All are theoretically guided by the provisions and intent of the three documents described above. A schematic of the Army's space organization is shown in Figure 1. As can be seen from the schematic, the Army space effort may be broken into five general categories: Staff, Operators, Combat Developers, Missile Defense, and Materiel Developers.[21] Each of these elements work for different bosses within the Army organization, and each have different responsibilities for the implementation of the Army Space Policy as outlined by the ASMP.

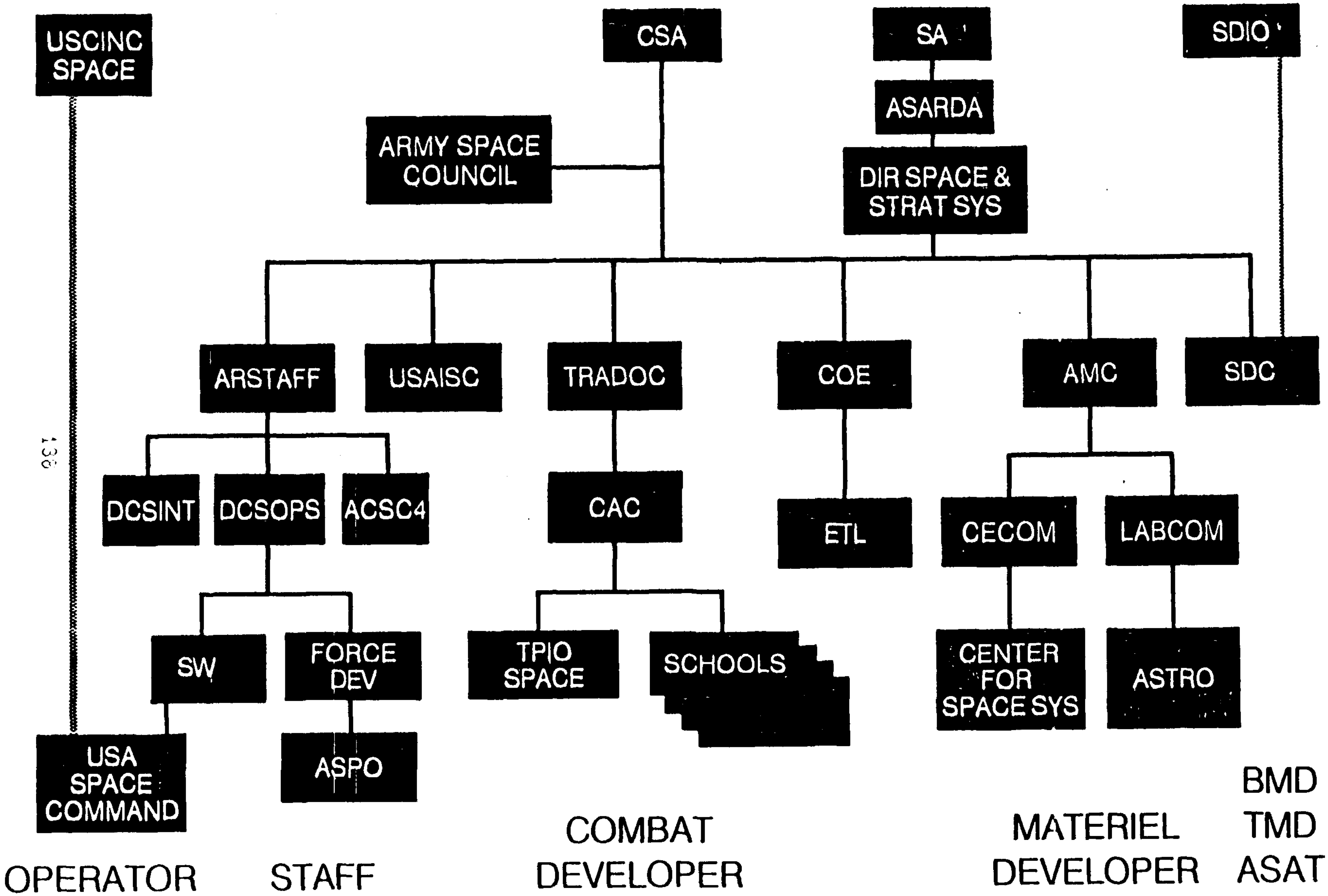

Figure 1. - Army Organization for Space

The Army Space Council is a continuing HQDA departmental committee, chaired by the Vice Chief of Staff, which provides recommendations and guidance through the Chief of Staff to the Secretary of the Army regarding all Army space related activities. Examples of these activities include current and future Army activities in space, Army participation as a component command of USSPACECOM, and space developmental programs. It is composed of members of the Army staff, field operating agencies, and MACOM representatives as appropriate.[22] The council's charter is basically to focus the Army's space policies, concepts, doctrine and requirements, and assist the development of manpower, training and materiel programs.[23]

The primary operator within the Army space effort is the Army Space Command (ARSPACE). Activated in 1988, it is the Army component command in USSPACECOM; as such it provides an Army perspective in all planning which is done for DOD space support to land forces and for strategic defense, and integrates Army requirements into USSPACECOM's planning and operations. ARSPACE is given the specific mission of providing operational planning for Army participation in the nation's space program, assisting the Army in planning for and obtaining space support, and coordinating the execution of approved Army space programs. In the Army space organization, it reports to the Deputy Chief of Staff for Operations (DCSOPS) through the Space and Special Weapons Directorate. DCSOPS is the focal point for space activities on the Army staff.[24] ARSPACE is organized as shown in Figure 2.[25] One of the principal responsibilities of ARSPACE is the conduct of communications payload and platform control of the nation's DSCS satellites. It also operates the Ground Mobile Forces Satellite Communications (GMFSC) ground terminals, assisted by its Regional Space Support Centers (RSSC), which allow access to the DSCS

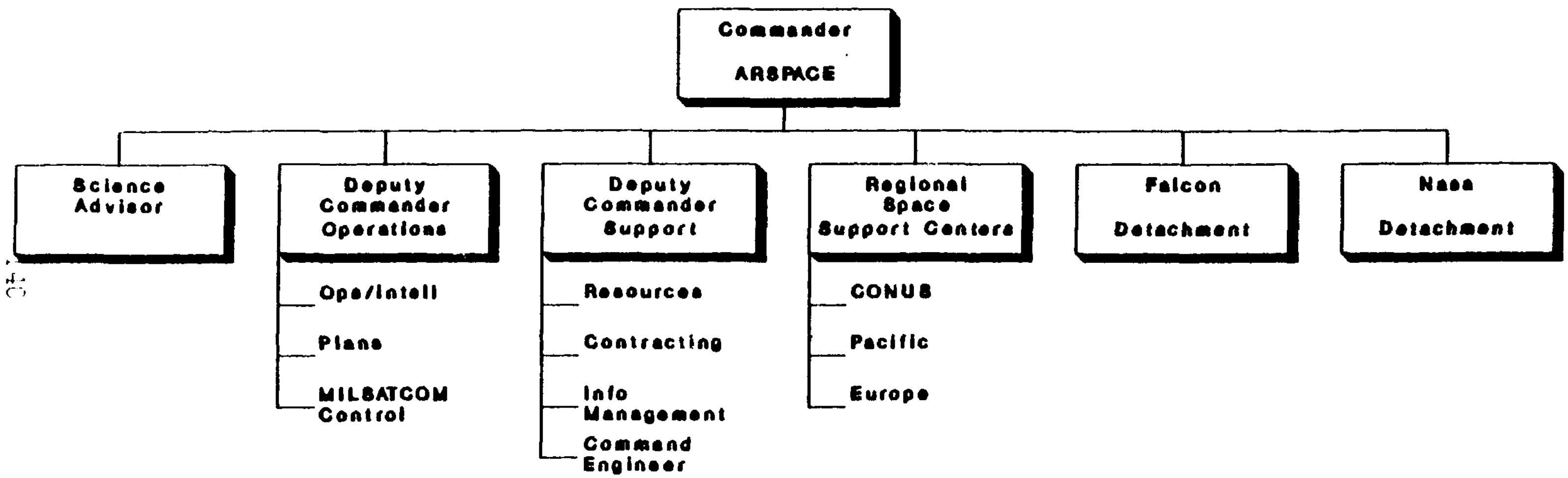

Figure 2. - Army Space Command

network.[26] It also 'owns' the Army space detachment working at NASA's Johnson Space Center in Houston. Eventually, it will be responsible for operation of the ground-based portions of the Strategic Defense System, such as ground-launched or DE ASAT weapons.[27]

One of ARSPACE's significant contributions to making the Army at large more aware of what space can do for it, following the lead of the Army Space Institute (ASI), is the effort known as the Army Demo Program. This program actually takes equipment designed to make the benefits of space technology available to the tactical user, often using Non-Developmental Items, and shows unit commanders what can be done with it and how it can enhance the unit's combat effectiveness. It was under the purview of this program that the GPS first became widely known, and which introduced the SLGR to many units. The program also demonstrated communications equipment and weather terminals which could be used at the tactical level. It is safe to say that had the Army Demo Program not occurred, the innumerable SLGRs and weather terminals which found their way to Saudi Arabia to support DESERT STORM would not have provided the assistance to the Army that they ultimately did.

As the Army's proponent for training, doctrine and combat developments, the Training and Doctrine Command (TRADOC) has developed the operational concept for Army space operations. This is embodied in the Army Space Operational Concept, a document which was published by TRADOC in 1988. Its purpose is to provide the connectivity between Army missions, space policy and AirLand Battle doctrine. As such, it states that:

- space operations are a logical extension of the battlefield
- space systems offer the commander a substantial increase in operational capabilities

- space control and use are directly linked to success on the terrestrial battlefield

- space-based command and control systems could provide the means for true battlefield synchronization of all combat functions

- space provides a unique view of the battlefield that offers the commander significant operational and tactical advantages

- space basing provides potential security advantages in support of all combat functions[28]

This concept is the recognition that Army access to space and the benefits of its technology must be secured if the full potential of AirLand Battle doctrine is to be realized.[29]

The actual TRADOC office which does space planning is the TRADOC Program Integration Office for Space (TPIO-SPACE), formerly known as the Army Space Institute. TPIO-SPACE is a component of the Combined Arms Command at Fort Leavenworth. It is intended to be a focus for space-related combat developments and training between Headquarters TRADOC and all TRADOC centers and schools. As such, it establishes the space curriculum requirements for the schooling of the Army's officer corps, and ensures that those requirements are met. It also conducts limited studies to anticipate and act upon the future space needs of the Army.[30]

Army participation in the Strategic Defense Initiative is centered in the Strategic Defense Command (SDC). This organization is a R&D activity organized as a Field Operating Agency which reports directly to the Chief of Staff, not through the DCSOPS as do the other Army operators. It is responsible for the Army's portion of the SDI program, specifically Ballistic Missile Defense (BMD) and Theater Missile Defense (TMD). It is the proponent agency for the Army

Tactical Missile System (ATACMS) programs, and is responsible for the operation of the Army's space surveillance facility at Kwajelein Atoll in the Pacific.[31]

Army R&D and materiel development efforts are found in different areas of the Army organization. The Assistant Secretary of the Army for Research, Development and Acquisition oversees all Army space development efforts through the Director of the Space Strategic Systems office. The actual developmental programs, however, are divided between DCSOPS, the Army Materiel Command (AMC), and the SDC. DCSOPS is responsible for all R&D activities involving RSTA. It accomplishes this through the Army Space Program Office (ASPO) of its Force Development branch, and incorporates these development programs into the total Army space effort by means of the Tactical Exploitation of National Capabilities Program (TENCAP), which provides national intelligence support to tactical commanders in the field.[32] SDC is responsible for the R&D efforts involved with BMD, TMD, and SDI, as described in the previous paragraph. AMC runs the Center for Space Systems as part of its Communications-Electronics Command, and the Army Space Technical Research Office (ASTRO) as part of its Laboratory Command. Additionally, it commands the Missile Command and the Satellite Communications Agency. These commands are responsible for all other space R&D efforts except RSTA and strategic programs.

Linkage between Potential & Doctrine. The Combined Arms Command (CAC) at Fort Leavenworth is the principal actor among the Army's space organizations in the realm of relating space potential to warfighting doctrine. As such, it has provided an estimation of how space capabilities should be incorporated into Army doctrine in the TRADOC Space Activity Transition Plan, which it published in 1990. In this plan, CAC includes as annexes a set of transition programs for most of the functional areas described in the Army Space Architecture, i.e. Communications, RSTA, Navigation, Weather and Terrain, Aerospace Control, and Strategic Defense. Each of these transition programs identify the near and far-term capabilities of the particular functional area, the necessary near and far-term upgrades to achieve the far-term capabilities, the near and mid-term technologies which must be developed to achieve the far-term capabilities, and the actions required to make the transition happen. Taken together, these programs yield a broad-brush view of how the integration of technology and doctrine is to be accomplished.

The underlying principle of the Communications transition is the idea that only satellite communications systems meet the AirLand Battle requirements for beyond line-of-sight, highly mobile, responsive, reliable, secure, jam resistant and survivable communications. Other types of systems may fulfill some of those requirements, but not all. Consequently, satellite communications will play a larger and larger role in Army doctrine as time progresses. Much of this transition, known as the Integrated Survivable Network (ISN) Communications Roadmap, will be guided by the AMSSA architecture. The ISN Roadmap indicates how the systems described in Chapter 3, such as the MILSATCOM components and their successors like MILSTAR, are intended to complement each other over the course of the next thirty years.

Responsibility within the Army for the integration of those satellite communications systems highlighted in the ISN Roadmap into AirLand Battle belongs to the Signal Center. The tasks which the transition program indicates that the Signal Center will have to accomplish to fulfill this responsibility include becoming an active participant in the AMSSA process, demonstrating the potential to tactical commanders of the DARPA LIGHTSAT program, and ensuring that Army tactical communications packages are developed to link with MILSATCOM UHF, SHF, and EHF systems.

The transition program also identifies some of the systems which the Army will use to make the communications satellites accessible to tactical forces. Primarily these forces will use the SHF and EHF capable communications systems, since the UHF satellites of MILSATCOM, such as FLTSAT, AFSAT, UFO and LEASAT, will generally be devoted to other than theater tactical users. SHF systems, the current DSCS satellites and the follow-on DSCS-IIIC, will continue to provide multichannel Ground Mobile Force trunking via the Multichannel Initial System (MCIS) AN/TSC-85B/93B terminals for theater forces, although the channels will continue to be assigned on a priority basis. Consequently, it is currently foreseen that SHF service to Army users will probably remain at corps level and higher. Even if more SHF terminals were provided at the division and brigade levels, to include the Multichannel Objective System (MCOS) AN/TSC-XX terminals designed for use with the future DSCS-IIIC, the DSCS systems have insufficient channel capacity to support any more users. This problem with channel capacity should ease somewhat once the EHF systems become operational during the coming decade. EHF terminals to be used with the advent of MILSTAR include the AN/TSC-124, better known as the SCOTT described in Chapter 3, and the MILSTAR Manpack Terminal (MMT), a true single channel EHF satellite radio.[33] SCOTT will probably not become the primary means of communication for the tactical level commander, both due to its high cost (in excess of $1 million per terminal) and its limited procurement (only 222 terminals are scheduled to be purchased). Instead, the MMT will be used primarily at the corps and division levels.[34]

The Army is also actively investigating the abilities of LIGHTSATs, as described in Chapter 3, to supplement the existing satellite communications constellations. CECOM's Center for Space Systems is working with DARPA on the LIGHTSAT program to develop a family of such satellites which will be dedicated to the needs of, and be physically under the control of, the tactical commander. As currently planned, the communications LIGHTSATs will provide the connectivity between the tactical commander and the strategic communications systems. At the tactical level, Army multichannel tactical satellite terminals will be made to be compatible with the in-place Mobile Subscriber Equipment (MSE), thus permitting connectivity between non-adjacent units, and initial entry into undeveloped theaters.[35]

The growing dependence of the armed forces on the capabilities of the RSTA satellite systems is fully recognized by the Army. These space-based systems essentially allow the commander to 'see' outside of his area of operations, permitting a view of enemy activity which is typically one level above his own.[36] The means by which the information collected by these systems gets to Army commanders in the field is the Tactical Exploitation of National Capabilities Program. TENCAP permits the Army to more effectively accomplish the Intelligence Preparation of the Battlefield (IPB), including situation development and target acquisition. The RSTA transition program describes the hardware which is being developed to put RSTA products into the hands of tactical users.

Four systems are currently being developed and fielded under the TENCAP banner. The first system, the Electronic Processing and Dissemination System (EPDS), is designed to exploit Electronic Intelligence (ELINT) signals collected by the various RSTA sensors. It does this by providing correlated reports to corps and division over the area communications system. EPDS is typically considered the start point for future evolutions of ELINT-derived reports to be utilized at corps and below.

The second of the four systems, the Imagery Processing and Dissemination System (IPDS), provides the tactical commander with the ability to receive real-time digital imagery from the RSTA sensors. The fielding allocation of the IPDS is intended to be one per command echelon from corps and above.

The third system, the Enhanced Tactical User's Terminal (ETUT), is also to be fielded one per echelon corps and above. It serves as the interface between the corps HQ and the EPDS and IPDS. The ETUT is the actual system which provides the reports generated by the EPDS and IPDS to the tactical commander.

Finally, the Tactical High Mobility Terminal (THMT) is a mobile system designed to provide the tactical commander with the ability to correlate the data provided by EPDS and IPDS, much like the ETUT. It is intended to be the prime method of support for contingency forces entering an immature theater. Allocation plans for the THMT are still pending.

The RSTA transition program also discusses, in addition to TENCAP, the Army's evaluation of the use of small LIGHTSATs to support the national RSTA systems. These type systems are intended to provide the tactical level commander with the ability to obtain real-time surveillance and targeting information of his area of operation. They would be designed to be launched on demand of the tactical commander.

Responsibility for the incorporation of RSTA capabilities into Army doctrine at the tactical level has been given to the Army Intelligence Center. Its principal missions currently are continued support for the fielding of TENCAP systems, evaluation and development of LIGHTSATs, and interface with the SDC.[37]

The Navigation transition program is probably the most complete of those described in the Transition Plan. The Army clearly recognizes the need for accurate position location information. As described in Chapter 3, the primary means for obtaining position information is from the Global Positioning System (GPS). Although other systems remain available, such as Loran, Omega, and Transit, the Army at this point relies exclusively on GPS for navigation support.

A number of receivers are currently in use by the Army for obtaining GPS information, and a several more are under development. Three receivers built to military specifications are presently in the Army inventory. The first set, designated the AN/PSN-8, is a 17 pound man-pack GPS receiver built by Rockwell-Collins which is capable of receiving the GPS P code; its vehicular counterpart is the AN/VSN-8. The PSN-8 is about the size and weight of a standard AN/PRC-77 radio, and has enough battery power to operate continuously for up to 12 hours, or intermittently for up to 48 hours. The second military set is the AN/ASN-149 (V). This is a high dynamic aircraft set which comes in three variants, depending on the type aircraft in which it is mounted. The third military set is the AN/PSN-9, built by Texas Instruments. This man-pack set weighs about 10 pounds, and is also capable of receiving the GPS P code; its vehicular counterpart is the AN/VSN-9.[38]

Supplementing the three military receivers described above, the Army is using the commercial set, described in Chapter 3, called the Small Lightweight GPS Receiver (SLGR). The SLGR, procured from Trimble Navigation, weighs about 5 pounds, and is small enough to be held in the hand. It does not have the ability to receive the GPS P code signal. Despite this limitation, SLGRs were used extensively by all types of U.S. forces during the Gulf War. The Army initially purchased 506 SLGRs in 1989 for testing, and in June 1990 decided to distribute them permanently to Army contingency forces. A supplemental purchase of 1000 sets was made in August 1990. Additionally, a second type of commercially procured set made by Magellan Corporation is in use by Army ground forces.

Other receivers and GPS receiving systems are currently under development by the Army. The Precision Lightweight GPS Receiver (PLGR) is billed as the next generation SLGR. The Enhanced Position Location and Reporting System (EPLRS) is a GPS driven system designed to support command, control and communications, while the Automated Integrated Survey Instrument (AISI) is a GPS driven system to support topographic surveying. Finally, the Army is conducting tests, mirroring practices being used in the commercial trucking industry, of a two-way GPS driven system of satellite-based tracking and communication. GPS transponders placed on trucks are monitored by a central control station to keep track of the trucks' status and location. The system has been tested in Panama, the National Training Center, and at Colorado Springs.[39]

Weather and terrain analysis are crucial to the Intelligence Preparation of the Battlefield, and the transition program describes how that will be facilitated. The military's DMSP satellites, and the various civilian weather systems described in Chapter 3 such as GOES, TIROS and Meteor, provide this support. Currently, all Army weather information from DMSP satellites is provided by the Air Force, a procedure which has not always proven responsive or adequate. To alleviate this constraint, some testing was conducted in 1989 with a Small Tactical Terminal (STT) to obtain weather information for tactical commanders from the DMSP satellites; efforts are now ongoing to field these terminals by 1994. Additionally, the Army has purchased commercial weather satellite receivers to obtain weather data from civilian systems.[40]

Ultimately, the Army intends to develop a weather processor called the Integrated Meteorological System (IMETS). This terminal, intended to complement the STT and be in the field by the year 2000, will link both civilian and military weather satellites with surface sensors and aerial weather platforms.

Most terrain analysis is conducted by satellite systems with multispectral imagery (MSI) capabilities. Currently, some of the RSTA satellites have this capability, in addition to civilian systems such as Landsat and SPOT. The Army currently uses Terrabase as its earth modeling database software, but the transition program discusses bringing on line the Combined Arms Mobility Modeling System (CAMMS), which has increased data storage capabilities. Together, these systems will provide terrain data and MSI for users at division level and above. The Army intends to improve on these capabilities of its terrain analysis systems by means of the Digital Topographic Support System (DTSS), which is designed to be in the field by 1998.

The goal of the work in the fields of weather and terrain analysis is a combined use of the data provided by the separate satellite systems. Ideally, such a system would include real-time weather data, such as that obtained by the DMSP microwave sensors, and the multispectral imagery obtained by the earth monitors.41

The remaining two programs discussed in the Transition Plan, Aerospace Control and Strategic Defense, have already been covered as developmental programs in Chapter 3. Briefly recapping, Aerospace Control is currently focusing on the development of an ASAT system in accordance with the directives laid out in JCS Pub 2. The Army's Air Defense School is the proponent for this system, and is developing the acquisition documentation required for its eventual fielding. The SDC is the actual materiel developer for the weapon system.

Strategic Defense in the Army is the responsibility of the SDC, with ARSPACE being the ultimate operator of the systems which are developed. Some of the Army systems currently in research and development include the Ground Based Radar (GBR), the Ground Based Interceptor (GBI), and the Ground Based Surveillance and Tracking System (GSTS), which were described in Chapter 3. Again, the Air Defense School is the Army's proponent for developing these systems.[42] Although a space-based fire support system which has offensive capabilities would seem to be a logical development, the transition programs indicate that only defensive systems are currently under development.

In addition to the linkages described above as part of the TRADOC Space Activity Transition Plan, the Army has initiated other efforts which affect how space will be incorporated into the AirLand Battle. Chief among these are the Army Technology Base Master Plan (ATBMP), a three volume document published over the signatures of the Secretary of the Army and the Chief of Staff which describes itself as "a road map to the versatile, deployable, and lethal Army of [the] future,"[43] and the Army Tactical Command and Control System (ATCCS).

The ATBMP is the Army's strategic plan for the technology base. It is updated annually. A relatively new document, the 1990 version is only the second edition to be published. Volume I is unclassified and contains chapters describing strategy, systems and technology demonstrations, key emerging technologies, the science base, systemic problems, supporting capabilities, and interfaces. Volumes II and III are more oriented toward the Army budget and Program Objective Memorandum process, and with long range research, development and acquisition strategies. Volume II, also unclassified, discusses science and technology objectives, AirLand Battle Future, next generation systems, advanced technology transition demonstrations, battlefield functional mission area capability package definitions, and additional technology demonstration. Volume III is classified and describes in more detail the Army's budget, science and technology objectives, and a further discussion of the advanced technology transition demonstrations.[44]

Only certain portions of the ATBMP deal specifically with space. Volume I contains three sections dealing specifically with space or spinoffs of space developments. In the section of Key Emerging Technologies, it highlights the need for satellites which may be launched 'on demand' and provide real-time communications and RSTA support to Army tactical commanders.[45] In other sections, it also describes the applications of directed energy technology to the battlefield, and discusses some of the developmental areas for which the Army's Strategic Defense Command is responsible, such as kinetic energy weapons, enhanced sensors, and battle management systems, which may be equally applicable to the AirLand Battlefield.[46]

The ATCCS, commonly known as 'Sigma Star', is the architecture for an integrated command and control system at the brigade, division and corps levels. In general, 'Sigma Star' divides the tactical command and control system into five Battlefield Functional Areas (BFA): Maneuver, Air Defense, Combat Service Support, Intelligence and Electronic Warfare, and Fire Support. The relationships between each of these BFAs is shown schematically in Figure 3.[47] The familiar name, 'Sigma Star', derives from the shape of the schematic.[48]

Each of the BFAs interrelate at three levels of tactical command, both horizontally and vertically within the architecture. Thus, at the division level, the Maneuver BFA would exchange information with the division Fire Support BFA, while simultaneously exchanging information with the Maneuver BFA at the corps and brigade levels. Each BFA has an associated computer information

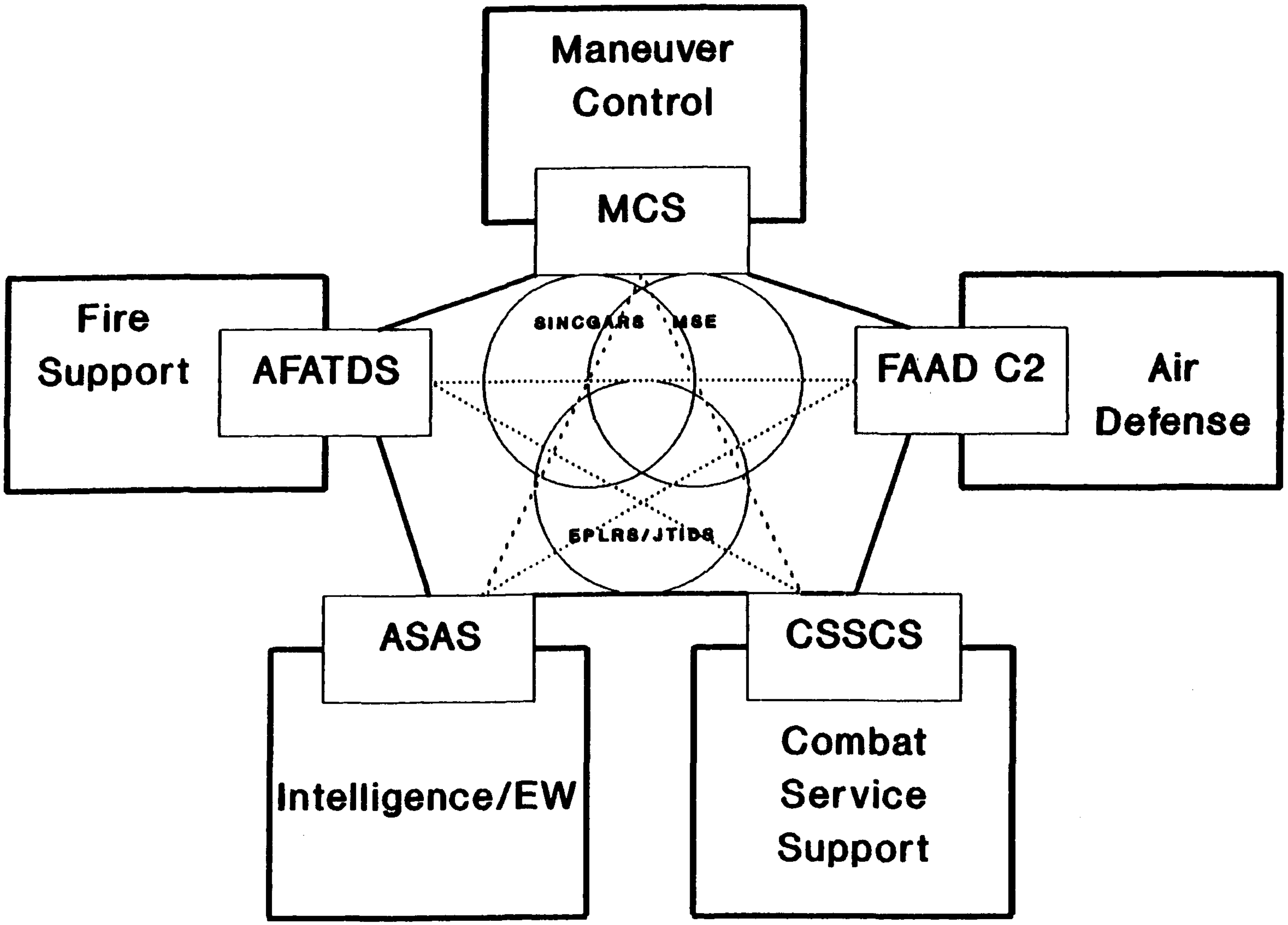

Figure 3. - Army Tactical Command & Control System

system which accomplishes this interrelationship, in addition to correlating the data entering the BFA and providing standardized reports and messages to the commander. The associations of each BFA with its information system are indicated in Table 3.

TABLE 3. - Association of the Battlefield Functional Areas and the Information Systems of 'Sigma Star'

Battlefield Functional Area	Information System
Maneuver	Maneuver Control System (MCS)
Air Defense	Forward Area Air Defense Command & Control (FAAD C2)
Combat Service Support	Combat Service Support Control System (CSSCS)
Intelligence & EW	All Source Analysis System (ASAS)
Fire Support	Advanced Field Artillery Tactical Data System (AFATDS)

Each may also be seen on the schematic in Figure 3. Currently, only the Maneuver Control System has been fielded; the other four are in various stages of development. Ideally, when all are complete, each will be capable of relaying information to or querying any other BFA with the system.

To facilitate these interfaces, three types of radio communications are utilized by 'Sigma Star'. These three are the Area Common User, using Mobile Subscriber Equipment (MSE), a kind of cellular phone network for the battlefield; the Common Net Radio, using the Single Channel Ground and Airborne Radio System (SINCGARS); and the Army Data Distribution System, which uses the

EPLRS discussed previously in this chapter, and the Joint Tactical Information Distribution System (JTIDS).[49] Together these communications networks provide the connectivity which the various BFAs of 'Sigma Star' require to pass information back and forth, both verically and horizontally, in order to make the entire system viable.[50]

As the ATCCS is being designed, efforts are being made to provide a means to insert information gathered by space assets into the BFAs via the communications networks. Ideally, RSTA systems will interface with the ASAS, GPS systems with the MCS, and Weather and Terrain Monitoring systems with both. This 'sensor fusion' is intended to have a synergistic effect, enhancing the overall importance of the information available in 'Sigma Star' and making it greater than the sum of its individual pieces of data.

All together, the implementation of 'Sigma Star' is programmed to cost the Army approximately $20 billion through 1998.[51] Once implemented in its entirety, it should provide the tactcal commander with a real-time ability to see the battlefield, viewing with clarity both his and the enemy's forces. Thus far in its development, significant compatability problems have surfaced with the software for each node. Until these are resolved, progress toward complete fielding of the system will not be made. Since 'Sigma Star' is ultimately a system of systems, probably the single biggest risk with this program is that it will be only partially fielded.

Army Space Education. The other responsibility of the Combined Arms Command at Fort Leavenworth, and TPIO-SPACE specifically, is the development of training programs about the Army's space concept. These programs, which are to be taught in the TRADOC school system, are designed to train personnel in the use of space assets to enhance the execution of AirLand Battle doctrine. Currently, this is a three-tiered schooling process.

First, at the introductory level, is a 3 hour block of instruction taught to all Army officers at the Officer Advanced Courses. This block of instruction is currently under development by TPIO-SPACE, with an intended implementation date of 1992. When implemented, it will be the responsibility of the individual Advanced Courses to ensure its effective execution. Additionally, a subsequent 4 hour block is included in the Command and General Staff College (CGSC) curriculum for all officers, with an additional optional 90 hour block at CGSC which leads to the awarding of the Space Operations Additional Skill Identifier, 3Y.

At the intermediate level, five separate courses are available for personnel who require an operational level of knowledge about space systems. These courses include a 3 day Army Space Action Officer Course taught annually at Fort Leavenworth; a 3 week Joint Space Fundamentals Course taught at Peterson AFB in Colorado; a 4 day Joint Space Intelligence/Operations Senior Course taught at Peterson AFB; a 2 week Joint Space Intelligence/Operations Course taught at Peterson AFB; and a 3 and a half month Undergraduate Space Training course taught at Lowry AFB in Colorado. These courses are intended to give selected Army officers the ability to understand how space assets can enhance the effectiveness of AirLand Battle doctrine.

At the advanced level, selected officers receive advanced civil schooling or participate in training with industry programs. The intent of this training is to develop officers for involvement in applying mature and emerging technologies to Army space needs.[52]

Outside of the sponsorship of TRADOC, little education on space and space operations is conducted within the Army for its officer corps. Two cases in point lie at opposite ends of the officer spectrum. At the near end, cadets at the U.S. Military Academy receive no compulsary instruction on Army space operations; there are two optional electives offered, typically subscribed to by about thirty cadets annually, but these courses deal primarily with orbital mechanics and the space environment, not with Army uses of space technology. At the far end of the spectrum, the Army War College has a curriculum which is similar to that of the Command and General Staff College, with all students receiving a short overview of space systems and capabilities, and optional electives on space being available for those officers who are interested.

It seems evident that the Army institutionally has conceded the need for space technology to be incorporated into its day to day operations. As discussed in the chapter, a variety of organizations have been established to implement the Army Space Policy and ensure its support of AirLand Battle doctrine, and numerous systems have been brought into the inventory or are under development to facilitate that action. How well and how effectively this incorporation is being done is the subject of Chapter 6, "The Army's Role in Space."

NOTES

[1]David Lupton, "Space Doctrines," Strategic Review 11 (Fall 1983): 37.

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[3]Ibid., 40-44.

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[5]Ibid.

[6]Ibid., 41-44.

[7]Alan J. Parrington, "U.S. Space Doctrine: Time for a Change?", Airpower Journal 3 (Fall 1989): 59.

[8]Kenneth A. Myers and John G. Tockston, "Real Tenets of Military Space Doctrine," Airpower Journal 2 (Winter 1988): 64.

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[14]U.S. Department of Defense, The Joint Chiefs of Staff, JCS Pub 2: Unified Action Armed Forces (UNAAF), (Washington DC: U.S. Department of Defense, The Joint Chiefs of Staff, December 1986), 2-6.

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[16]U.S. Department of the Army, FM 100-18: Space Operations, (Washington DC: U.S. Department of the Army, August 1990), 6, 7.

[17]U.S. Department of the Army, TRADOC, TRADOC Space Activity Transition Plan, (Fort Leavenworth KS: U.S. Department of the Army, 11 December 1990), B-1.

[18]Army Space Master Plan, xiii.

[19]TRADOC Space Activity Transition Plan, B-1

[20]Ibid., B-2.

[21]Schematic of the Army's Organization for Space is provided by the courtesy of TPIO-SPACE at Fort Leavenworth.

[22]Army Space Master Plan, 5.

[23]Roe, 15.

[24]Army Space Master Plan, 8.

[25]Schematic of the ARSPACE organization is provided courtesy of TPIO-SPACE at Fort Leavenworth.

[26]FM 100-18, 18-19, 38.

[27]Ibid., 34.

[28]Army Space Master Plan, 29.

[29]Paul A. Robblee, Jr., "The Army's Stake in Emerging Space Technologies," Parameters 18 (December 1988): 115.

[30]TRADOC Space Activity Transition Plan, C-2, C-3.

[31]Army Space Master Plan, 9.

[32]Ibid., 14; also Pat Gagan, "The Army Space Command," Military Review 68 (March 1988): 48.

[33]Joseph T. Page, Jr., "The U.S. Army and Military Satellite Communications," Army Communicator (Fall 1989): 25.

[34]All of the information presented in the section discussing the Communications Transition Program, except as otherwise noted, is obtained from the TRADOC Space Activity Transition Plan, Annex D.

[35]Norman W. Styer Jr. and R.C. Ferra, "Space-Based C3I is Critical to Future Contingency Army," Army 40 (April 1990): 44.

[36]Ibid.

[37]All of the information presented in the section discussing the RSTA Transition Program, except as otherwise noted, is obtained from the TRADOC Space Activity Transition Plan, Annex E.

[38]Ibid., Annex F; also Doug Richardson, "Background to and Applications of NAVSTAR/GPS," Armada International 14 (June/July 1990): 72.

[39]All of the information presented in the section discussing the Navigation Transition Program, except as otherwise noted, is obtained from the TRADOC Space Activity Transition Plan, Annex F.

[40]Styer, 47.

[41]All of the information presented in the section discussing the Weather and Earth Sensing Transition Program, except as otherwise noted, is obtained from the TRADOC Space Activity Transition Plan, Annex G.

[42]TRADOC Space Activity Transition Plan, Annexes H and I.

[43]U.S. Department of the Army, Army Technology Base Master Plan, Volume I (Washington DC: U.S. Department of the Army, November 1990), iii.

[44]Ibid., ix.

[45]Ibid., III-17, III-19.

[46]Ibid., III-15, VII-8.

[47]Schematic of 'Sigma Star' obtained from David R. Gust, "Army Battlefield C^3I Using Satellite Communications," Signal 43 (May 1989): 58.

[48]Lawrence J. Dacunto, "Army Command and Control Initiatives," Signal 42 (November 1988): 65.

[49]Gust, 58; also Dacunto, 66.

[50]Page, 23.

[51]Dacunto, 65.

[52]TRADOC Space Activity Transition Plan, Annex J.

CHAPTER 6

THE ARMY'S ROLE IN SPACE:

CONCLUSIONS & RECOMMENDATIONS

We must hold our minds alert and receptive to the application of unglimpsed methods and weapons. The next war will be won in the future, not in the past.

General Douglas MacArthur
Chief of Staff of the Army, 1931

From an operational viewpoint, tomorrow's most pressing requirement is to make space systems more available and 'user friendly' to battlefield commanders.

General John L. Piotrowski, Jr.
CINC, U.S. Space Command, 1988

"We must hold our minds alert and receptive." These words of Douglas MacArthur are as true today as they were when he uttered them sixty years ago. The Army should continually bear them in mind as it develops and implements its doctrine. Often though, it seems that in trying to sort through the many new technologies becoming available, we have a difficult time identifying those which are worth pursuing and separating them from those which are not. We routinely can't see the forest for the trees.

Our nation's move into space has truly opened up vast areas of great technological promise for the future of our society, civilian and military alike. Indeed, that promise is changing how the world turns in ways which were unfathomable a mere fifty years ago. The methods by which war is waged will certainly not remain untouched by this change. So it seems reasonable to ask: Is the Army 'alertly and receptively' acting to make use of that promise?

The purpose of this thesis has been to answer that very question: How well does Army warfighting doctrine utilize the potential of space? To be able to ultimately answer that, there are three other questions which must first be answered. First, what potential benefits does space hold for the Army? In other words, should the Army even be concerned with what goes on in space, or is the nation's space program developing technologies which have applications useful only to the other armed services or to the civilian world? Chapter 3 of this thesis sought to provide the basic technical information with which an informed answer to this question could be developed. Second, does the Army's warfighting doctrine, as embodied in AirLand Battle and AirLand Battle Future, have any areas which explicitly depend on space assets or which could be significantly enhanced by the utilization of such assets? Chapter 4 presented the background for this answer by examining the basic principles of the Army's doctrine in its present and future forms. And third, _if_ space technology does hold some potential benefits for the Army, and _if_ AirLand Battle and AirLand Battle Future can make use of them, does the Army recognize that to be the case and is it actively seeking to effect the integration of doctrine with technology? Chapter 5 discussed the systems and organizations which the Army currently employs for this purpose. Once answers to these three questions have been determined, the prime question can then be examined.

The Potential of Space

Does space technology hold out any potential benefits for the Army? Chapter 3, "The Potential of Space," presented in brief the elements which make up the space program of the United States. Much of that program does not have direct applicability to the Army at the operational and tactical levels of war, which are the the realm of AirLand Battle doctrine. Naturally, the Army is concerned primarily with the systems of the National Security space sector. The Civil space sector and the Commercial space sector have only tangential applications for the Army, such as earth sensing satellites like SPOT and Landsat, or weather satellites like GOES.

In the National Security space sector itself, many of the systems involved are dedicated primarily to providing support to the nation at strategic levels. For example, the RSTA systems provide data for the national intelligence community; if any of that data gets down to Army commanders at the operational or tactical levels, it is typically only after it has been analyzed and released by the strategic users. Likewise, much of the space communications systems which comprise MILSATCOM are dedicated to the use of the National Command Authority and other national level users, or provide the means for relaying early warnings of missile attack. Although theater level commanders are users of the MILSATCOM components, they do so on an as needed basis only. Tactical level users are currently virtually proscribed from using satellite communications systems because of channel limitations. Nonetheless, the near real-time intelligence data obtained from the RSTA systems and the over-the-horizon capabilities of communication satellites could certainly be utilized by Army operational and tactical users if the existing systems were to be improved or supplemented, or if the means of accessing the existing systems were modified.

The Army does actively use the Global Positioning System for navigation and position locating purposes at the present, and that use will undoubtedly increase further still as a result of successful exploitation of that system during the operations of DESERT STORM. Access to GPS is widespread, with SLGRs being practically omnipresent among the forces in Saudi Arabia. Troops have been extremely receptive to their use, with new and innovative applications of the system being devised constantly. GPS can permit precise minefield and obstacle emplacement, increase a commander's flexibility when using graphic control measures, simplify the conduct of a passage of lines or the actions of a quartering party, even assist the navigation of watercraft units of the Transportation Corps on inland waterways.[1]

The use of weather satellites and earth sensing satellites for mapping also was demonstrated during the Gulf War, although Army access to the military systems described in Chapter 3 is nearly as limited as its access to RSTA assets and MILSATCOM. To compensate, the Army relies heavily on civilian weather and earth monitoring systems, like GOES and Landsat, for the information it needs to produce up-to-date maps and to develop accurate battlefield estimates. Nonetheless, despite these systemic problems, each of the types of space systems discussed in Chapter 3 has applications which the Army is endeavoring to exploit.

Thus, the first of the three supporting questions may be answered: space systems indeed do have the potential to provide benefits for the Army, at the operational and tactical levels, which could be utilized to significantly enhance its effectiveness.

The Army's Warfighting Doctrine

Do AirLand Battle and AirLand Battle Future depend in any way on space support for success? Chapter 4, "The Army's Warfighting Doctrine," presented an overview of AirLand Battle doctrine and its evolutionary outgrowth, AirLand Battle Future. Both doctrines are explicitly offensive in nature, and deal with the operational and tactical levels of war. Strategy is a level above; AirLand Battle is actually the Army's means of implementing strategy.

Key to the success of both doctrines is effective Command and Control of the forces in the field, and the ability to successfully see and engage enemy forces at extremely long ranges. These Deep Operations must effectively coordinate the use of artillery and air assets, and reconnaissance by unmanned sensors, by cavalry units and by long range patrols. Both of these functions will become more difficult, yet more essential, as the doctrine evolves. Fewer units on the future battlefield, which have to be tightly choreographed to ensure that they can mass quickly to defeat an enemy, yet retain the ability to disperse rapidly to prevent being destroyed by a larger force, will necessarily require effective, reliable communications with their headquarters and with each other, and will require accurate means of position locating and navigation. The larger enemy formations will necessarily have to be identified and tracked as far from friendly forces as possible, and engaged at longer ranges with more accurate and more lethal fires to whittle them down to size before they are actively attacked by friendly maneuver forces.

Both doctrines recognize that space technology can enhance their Command and Control and their Deep Operations. Satellite communications avoid the 'line-of-sight' problems which often inhibit standard FM communications. RSTA satellites can provide the information needed to watch enemy formations at long range, to target them for engagement by deep fires, and to assess the effectiveness of those fires once complete. Navigation satellites aid maneuver units in moving rapidly and accurately from point to point, often at night or under conditions of limited visibility, so that they can appear when and where the enemy is at a disadvantage. These navigation satellites enhance the effectiveness of the deep fires by accurately locating the fire support systems prior to the engagement. They then aid in speeding support to the attacking units, in the form of supplies and other assistance, by tracking supply vehicles and keeping people from getting lost. Weather satellites help predict not only what kind of weather patterns are due to arrive in the area of operations, but also when they will leave. AirLand Battle doctrine already utilizes some of these capabilities; AirLand Battle Future explicitly says that space technology will be essential if it is to be executed successfully.

It is interesting to consider the vulnerabilities of the warfighting doctrine to changes in the threat, in technology, and most important in the near term, in budget. In general, it may be said that the doctrine has adequately taken these changes into account. Indeed, the anticipation of these changes is really what is driving the evolution of the doctrine. The Army recognizes that it is not going to face a Soviet style threat in every area of operations around the world; AirLand Battle Future takes this into account with its changes in force structure from heavy forces to a heavy/light/SOF mix. The Army recognizes that the technology of war is evolving rapidly, and is taking steps to incorporate new technologies, such as kinetic energy and directed energy weapons, into its weapons systems of the future. It recognizes that it inevitably will have less money to work with in the future than it does now, as Congressional budget appropriations foretell, and is paring back and streamlining its force structure accordingly. It is safe to say that AirLand Battle Future owes its existence to these coming changes in the threat, technology and budget.

It is also interesting to consider how vulnerable the warfighting doctrines are to the hostile use of space technology. As described in Chapter 3, many nations of the world utilize space assets to some degree. A small handful utilize them to support their military; their number is growing year by year. The greatest vulnerability of AirLand Battle and AirLand Battle Future to space operations is in the realm of the commander's decision cycle. Space assets which collect intelligence, such as reconnaissance and surveillance satellites with a near real-time capability to gather information on communications nets, air defense systems, and the location of troop units, can allow the enemy commander to 'get inside' the friendly commander's decision cycle and effectively anticipate what his capabilities and intentions are on the battlefield. The only remedy for this would appear to be negating the systems which are gathering the intelligence from space, either by destroying the satellite itself, by eliminating its ground support facilities, or by disrupting its communications control links. This is part of the reasoning behind the development of the U.S. ASAT system and other active space defense measures. Fortunately, only the Soviet Union currently possesses the satellites and control systems which are capable of this, and no other nations appear to be developing the infrastructure necessary to exploit such near real-time reconnaissance, despite their improving access to such satellites as provide it. We can thus focus our attention in one direction.

Thus, in answer to the second of the three supporting questions: Army warfighting doctrine, now and in the foreseeable future, is and will be increasingly dependent on the utilization of space-based assets for its success.

Space in the Army

How does the Army currently use space technology in its operations? Chapter 5, "Space in the Army," described the present organizations and systems by which the Army incorporates space technology into its day to day operations. By and large, the Army leadership recognizes the potential which space holds for it and has created a number of agencies to control the many facets of its space activities.

Regretably, there is no clear, apparent, centralized agenda that these agencies follow, nor do they report to the same master or dance to the same tune. Some portions of the Army's space effort march to the beat of the strategic defense drum, while others march as low level tactical supporters. Some agencies view strategic and theater missile defense as of paramount importance, while others seek to simplify the tasks of the battlefield commander by providing his troops with terminals which can tap into the unseen space support network. Generally, these parallel programs fall under the auspices of the Strategic Defense Command (SDC) and the DCSOPS, respectively. Both offices direct separate R&D programs and seem to have priorities which often compete with each other for resources. Despite the presence of the Space Council, it seems that the two Lieutenant Generals in charge of the SDC and DCSOPS vie for influence in Army space operations with each other. What results is a relatively disorganized implementation of the Army's space policy, resulting in duplication of effort and ineffective progress toward fully exploiting space technology in Army activities.

Truth be told, some progress is indeed being made. The Army's space concept, for example, has charted a logical course through the coming decades which should lead to more effective measures being developed. It spells out a progression which should ensure that the Army acquires the terminals it needs to make space technology available to the tactical user, and that its needs are made known to the project managers who will be determining the specifications for the next generation of military satellites. The Army Demo Program has created tactical awareness of and interest in space systems. However, more energy will have to be channeled into ensuring that that space concept remains on course if the integration of technology and doctrine is to become reality.

Thus, the answer to the last of the three supporting questions can at best be given a qualified yes: the Army is indeed taking action to effect the utilization of space technology, but it isn't doing it well enough yet.

The Army in Space

The question posed by this thesis can now be answered. Based on the three questions above, we can conclude that space technology indisputably offers capabilities of which use can be made by the Army; that AirLand Battle and AirLand Battle Future both depend to varying extents on the utilization of space technology for successful execution; and that the Army recognizes both of these facts and is endeavoring, somewhat fitfully, to accomplish their integration.

Does Army warfighting doctrine effectively integrate the potential of space? The answer must be yes, insofar as the two can be integrated at the present, but there is certainly room for improvement.

It is important to consider how that improvement might be made. To do this, we must first recognize clearly that AirLand Battle is exclusively an operational and tactical doctrine; the U.S., in effect, currently has no strategic land doctrine despite attempts by the Army leadership to portray the Army as a strategic force. Thus, if the Army is to fully incorporate space technology into its warfighting doctrine, it is essential that the Army be looked at as an operational and tactical <u>user</u> of space services, rather than a strategic <u>operator</u> of space systems. This is not to say that the Army must parochially develop its own dedicated space systems; quite the contrary, the development, fielding and operation of national space systems is certainly the most effective and efficient way for DOD to create its required space infrastructure. The Army's prime concern, however, must not be to develop, field or operate those national systems, but to provide input as those systems are developed, and once they are fielded and operational, so that soldiers in the field may reap the benefits which that technology can provide.

Often this subtle distinction between operational and tactical use versus strategic operation gets overlooked in the great race to participate in space operations. It is more than just a question of semantics, however. To improve how well and how thoroughly the Army integrates the benefits of space technology into its warfighting doctrine, the focus for the Army's space program must remain at the operational and tactical level where it can do the most good for forces in the field. Army participation in space activities above and beyond this level which is conducted at no detriment to its operational and tactical users is certainly acceptable, but it must be viewed as a secondary priority to the Army's main focus. If the Army begins to involve itself in activities which do not relate directly to the operational and tactical levels of war, and if this is done at the expense in terms of allocated resources for those levels, then the full integration of doctrine and technology will never come about.

Already, the Army has shown a tendency to consider itself an operator of strategic space systems. It is now the operator of the communications control segment of DSCS. A great deal of manpower and money goes into this effort. Undeniably, this operation must be done. If the Army declines to accept the task, then another service will certainly do it and the Army will lose the funds and personnel slots which go with the task. However, the question must be asked: are more Army funds and personnel being devoted to this operation than are prudent, and could they be better utilized to develop and operate systems which will connect the tactical user to the space network? The Army now has nine astronauts in the Military Man in Space (MMIS) program; are these space-knowledgable officers aiding the nation at a global (i.e. strategic) level, or does their service help the tactical level commander in the field? Would they be better utilized directing programs to bring space down to the operational commander?

Similarly, other high visibility programs which are strategic in nature hold the Army's attention. For example, the Army is the proponent of the ASAT, a strategic weapons system, fully intending to field such a ground-based missile, train its personnel at the Air Defense School, and assign them to missile units commanded by ARSPACE. Additionally, the Army is to be responsible for organizing Ballistic Missile Defense battalions commanded by ARSPACE which will help provide strategic defense of the United States as part of the SDS.

Finally, the Army intends to develop and operate an instrumented National Range to support DOD and other government agencies in launching, tracking, and collecting data on missiles and space launches.[2] While these are functions which must be done, in accordance with the National Space Policy and the directives of the Joint Chiefs, they are operations which draw attention and resources away from the operational and tactical levels of war and focus them instead on the strategic, to the detriment of the soldier in the field. When faced with these requirements, the Army must make clear that its top priority is to put space services into the hands of the operational and tactical user. If the Army's warfighting doctrine is to be successfully supported by space technology, the focus must be kept there; the Army cannot afford to be the strategic operator of national space systems, particularly in these times of tight budgets and competing priorities.

The Army's Space Concept, as promulgated by ARSPACE, lays out a roadmap by which the Army can maintain the proper focus for its space program. The basic premise behind the concept is that in the near-term the Army must concentrate on obtaining the receivers and terminals which will put soldiers in contact with existing space systems. In the mid-term, it says that the Army must concentrate on obtaining the processors which will permit it to analyze the raw data provided by the space systems at the location where it is needed, without having to rely on outside agencies at the national level to process and disseminate the information. Finally, in the long-term, it says that the Army must concentrate on effectively providing input to the agencies which are developing the next generation of space systems, to ensure that the satellites will be capable of supporting Army requirements. Adhering to these general guidelines will enable the Army to keep its focus on supporting the soldier in the field at the operational and tactical levels of war, and not to get caught up in national strategic programs which will not provide that direct support.

The two areas in which space can play the most important role in enhancing the effectiveness of AirLand Battle and AirLand Battle Future fall under the headings of "Command and Control" and "Deep Operations." The successful incorporation of space technology into these areas must be the focus of those who guide the Army's space programs over the next several years.

Command and Control. Command and Control is and will become increasingly important and increasingly difficult on the AirLand battlefield. Decentralization of authority will become common, with the commander's intent and mission orders guiding the action as the battle progresses. What might the Army do in the future to better use space technology to enhance its Command and Control ability?

At the present time, if we examine the functions of communications, navigation, weather and earth sensing, and reconnaissance, space technology plays a relatively small role in Command and Control. Communications at the tactical level, and even at the operational level by and large, still rely largely on standard FM, line-of-sight radios. These radios are limited in range and highly susceptible to interference from terrain masking. Ground-based improvements to this situation are coming, principally in the form of Mobile Subscriber Equipment (MSE). Even with this users must still be within a relatively close range of the system's relay stations to enter the net.

The biggest present use of space technology for Command and Control purposes involves position locating and navigation via the GPS. As discussed in Chapter 3, virtually all Army aircraft, artillery units, and a significant number of maneuver and logistics units were equipped with SLGRs during the Gulf War. This enabled them to more effectively carry out the tasks assigned to them, minimized the time they spent looking for a particular location, and allowed commanders to accurately know the locations of the elements of their commands.

Very little use is currently made of weather data, geodetic data, or real-time intelligence data at the tactical or operational level. Primarily, this is because of an absence of terminals and processors in those units which can obtain the data directly. At the operational level, the situation improves somewhat. Terminals which can access civilian weather satellites, such as GOES or the Soviet Meteor, are routinely available at corps and above. Conspicuously absent are terminals which can access DOD weather satellites; consequently, the Army must turn to the Air Force Staff Weather Officer to get information from DMSP. Army operational level users can act to purchase earth data from Landsat, or ask that it be purchased from SPOT, as was recently done during DESERT STORM. By merging MSI data with digital topographic data, Army topographical units can produce maps, provide rough trafficability estimates, or even create three-dimensional perspective views which highlight observation and fields of fire from either ground or aerial levels.[3]

Access to raw data from national RSTA systems is extremely limited even for operational users, most often because the data is classified by national security authorities at a level above the 'need to know' of the operational user. A notable exception during the Gulf War was the early warning information provided to the Patriot batteries representing the theater's missile defense.

Increased emphasis on utilizing space technology can significantly enhance the operational and tactical commander's ability to effectively command and control his unit. The 'cellular phone' concept of MSE can be taken a step further via a large constellation of small communications LIGHTSATs which can conceivably entirely eliminate a tactical user's line-of-sight problem. As described in Signal, such a system is already being investigated by some commercial companies. Motorola Corporation, which helped pioneer the cellular phone proliferation, is working to develop Iridium, a global communications network composed of 77 small satellites in low earth polar orbits which will permit users to communicate instantaneously anywhere in the world using hand-held radio telephones. When operational, it will be capable of handling both voice and data transmissions. Using off the shelf technology, the entire Iridium system is projected to be operational by 1996 for the relatively low cost of $2.3 billion. Estimates on the cost of the individual radio telephones run as low as $1000.[4] The implications of such a system for the Army are well worth investigating.

'Sensor fusion' will be the key to successful integration of technology and doctrine for command and control purposes. The 'Sigma Star' concept described in Chapter 5 will revolutionize command and control processes once it is complete. To ensure that this network incorporates the full potential of space assets, care must be taken to guarantee that each of the separate components of the star are fully capable of talking with each other instantaneously, with no logjams due to limited channel capacity, line-of-sight restrictions, or software incompatibilities.

The implications of such an operational system are thought-provoking, to say the least. Consider GPS. Position locating information provided by the GPS would feed directly into each of the five control systems of the star. If we look only at the Maneuver Control System (MCS), the positions of every vehicle in the force would be available to the commander immediately. By equipping each vehicle and each platoon size element of ground troops with a SLGR to continuously determine its location, and by incorporating a position signal reflecting the GPS information along with the voice signal in the radio transmission, the position status of the unit could be updated each time the vehicle communicates. The soldier would not even have to think of reporting his location anymore, and the commander would not have to ask for it; by simply talking to each other, the two soldiers would unconsciously inform the MCS of the location of the unit. Once entered into the MCS, the information would be available to any other system of 'Sigma Star'.

Similarly, intelligence data, collected by either national RSTA assets or by reconnaissance LIGHTSATs launched under the control of the operational commander, would feed in real-time or near real-time into the All Source Analysis System (ASAS). From there early warning data could be instantaneously accessed by the Forward Area Air Defense Command and Control (FAAD C^2) system, much as the Patriots have recently done in DESERT STORM. Other threat data could be accessed by the Advanced Field Artillery Tactical Data System (AFATDS) for fire missions. Simultaneously, AFATDS would know from the MCS the location of all friendly units; 'friendly fire' could become a much less serious threat than it is on today's battlefield.

Other space assets, such as weather satellites from the DMSP and its civilian and foreign counterparts, and earth sensing satellites like Landsat, could feed information into the star to make the present Intelligence Preparation of the Battlefield (IPB) process seem absolutely archaic. Identical products to those now laboriously produced during the IPB, products highlighting the soil trafficability of an avenue of approach or the obstacles present in an area of operations, for instance, could be continuously available and constantly updated by incorporating information on weather systems, land forms and ground conditions via 'Sigma Star.' The addition of an Iridium type communications system, above and beyond the three systems already planned (MSE, SINCGARS, and EPLRS/JTIDS) for 'Sigma Star,' will help to ensure that the system is as capable, reliable, invulnerable, and flexible as it can possibly be.[5]

Deep Operations. The other key to successful execution of AirLand Battle and AirLand Battle Future, Deep Operations, is the second area which can be effectively enhanced by the incorporation of space technology. Generally, Deep Operations may be subdivided into three parts: Deep Fires, conducted by Army and Air Force air assets and long-range artillery, which are intended to delay the arrival of follow-on echelons of the enemy force and disrupt his command and control and logistics operations; Long-Range Surveillance, conducted on the ground by unmanned sensors and cavalry units, and by airborne monitors such as the Joint Surveillance Target Attack Radar system (JSTARS), which are intended to provide early warning of enemy ground movements with indications of the size and direction of those forces; and Special Operations such as surveillance, demolitions, and sabotage, conducted principally by Special Operations Forces, which are intended to amplify the disrupting effects of the Deep Fires and increase the early warning provided by the Long-Range Surveillance.

Deep Fires currently are provided principally by Air Force elements. At the operational level, they strike targets hundreds of kilometers in the enemy's rear areas, targeting command, control and communications nodes, logistics storage facilities, and troop formations, which will significantly affect his ability to wage the close battle in the near future. Army assets also provide Deep Fires, although they do not have the range of the Air Force strike assets. Army elements are principally attack helicopters and long-range artillery such as the Multiple Launch Rocket System (MLRS). Targets are those which can have a more immediate impact on the close battle, such as artillery and missile launchers, air defense systems, and headquarters elements. Targeting information is often provided by intelligence analysts using national intelligence assets, supplemented by reports provided by the Long-Range Surveillance and Special Operations assets. Most is usually not even near real-time information.

Space systems can potentially significantly enhance the effectiveness and lethality of these Deep Fires. Using position location information from the GPS, artillery units, to include MLRS and ATACMS, will be able to benefit from 8 meter position and .1 degree direction of travel accuracy for use in the fire solution without having to rely on survey data or on-sight position estimates. Additionally, the Forward Observer will be able to obtain a 10 digit coordinate for the enemy's position.[6] Data provided by the All Source Analysis System or 'Sigma Star', to include enemy location obtained by reconnaissance and earth monitoring satellites and weather data provided by DMSP assets, will complement the GPS to permit fires of increasing accuracy.

Additionally, our present ground-based fire systems could be supplemented by space-based fire systems. Using spin-offs of SDI technology, such as kinetic energy weapons like the HVG or directed energy weapons like lasers and particle beams, coupled with extraordinarily sensitive space-based radar systems for target acquisition, Deep Fires could conceivably so disrupt all enemy follow-on forces and reserves, even as ground forces are defeating committed first echelon units, that the succeeding echelons will have no influence whatsoever on the Close Battle. Additionally, the National Aerospace Plane (NASP), presently under development and typically viewed as a long haul asset for lifting payloads into

LEO, could conceivably be configured to haul troops or equipment, or armed with SDI weapons systems to participate actively in the deep battle.

Long-Range Surveillance operations likewise can be enhanced by the increased use of space technology. The principal limitation currently at the operational and tactical levels is the lack of real-time access to the national RSTA assets. To compensate, users at those levels rely on airborne sensors such as JSTARS to identify and monitor enemy troop movements in their rear areas, and on earth data obtained from unclassified sources such as Landsat. JSTARS is the Air Force system designed to detect movement on the ground at ranges in excess of 100 kilometers. Users then supplement this with information gleaned from ground sensors and reconnaissance forces.

It must be assumed that the national RSTA assets will remain dedicated to strategic intelligence, just as the components of MILSATCOM will remain dedicated primarily to strategic communications. To get around this fact, operational commanders will have to be capable of launching LIGHTSATs to provide reconnaissance and communications support for the duration of their campaign. The reconnaissance LIGHTSATs will have to be equipped to employ Multispectral Imagery (MSI) and Synthetic Aperture Radar (SAR) to effectively monitor enemy formations, and their products will have to be classified no higher than secret if they are to be usable at the tactical level. With resolution capabilities on the order of the newest SPOT, these LIGHTSATs would be capable of detecting troop concentrations, missile sites, and individual vehicles.[7] They should also be capable of on-board processing using "Cray-in-a-can" technology, to reduce the amount of required ground processing equipment in the theater. The communications LIGHTSATs will have to be capable of working in concert with strategic EHF systems such as MILSTAR, or to supplement an Iridium type constellation as described above. The employment of such networks, and the integration of the information they provide to the 'Sigma Star' system via ASAS, will enable operational and tactical commanders to better evaluate their opponent and make their plans accordingly.

Special Operations Forces already utilize a great deal of space technology in accomplishing their missions. For instance, they routinely use channels on the DSCS satellites for communications and are equipped with the portable ground terminals required to do this. They use the GPS as standard procedure to determine their location; they are equipped with SLGRs to accomplish this. In parallel, they also use GPS to determine the location of enemy units for engagement by Deep Fires; during the Gulf War, SOF elements reportedly moved covertly to enemy artillery and command and control units, determined their location with SLGRs, and passed it on to those guiding the air campaign. Of the three basic components of Deep Operations, SOF elements most completely have integrated space technology into their day to day operations. Consequently, with the exception of newer terminals which are smaller, more durable, and more reliable, their activities in the future will likely not be much changed from what they are now.

Certainly the Army's budget will affect how well and how quickly these enhancements could be implemented. If fiscal cutbacks become extremely severe, the Army's ability to integrate space technology with doctrine will be imperiled. Steps must be taken by the Army leadership to identify those space programs which contribute to the support of Command and Control and Deep Operations, and protect them from the anticipated budget cuts. Throughout the process, the emphasis must remain on focusing Army space programs on the operational and tactical levels, and opting out of the strategic programs which will either be funded anyway, or will be picked up by one of the other services. Plans must also be prepared to supplement or supersede Army space programs which are designed to permit access of tactical units to space systems, but which are either reduced or eliminated, with purchases of Non-Developmental Items from civilian sources which do not completely meet the military specifications of the eliminated systems, yet which can still put the tactical user in touch with the space network.

Recommendations

Maintaining the proper focus for its space program will be one of the Army's significant challenges over the next decade. To facilitate the incorporation of space technology with warfighting doctrine and improve the integration of the two in the future, a number of concepts should be emphasized by the Army. In some cases, these are concepts which are already being implemented and so need only be maintained and encouraged. In other cases, the concepts are either absent or not emphasized at all.

> 1. The Army must wholeheartedly accept that it is a tactical and operational user of space services, and not a strategic operator of space systems. It must be willing to give up those strategic programs which it currently operates, such as DSCS, ASAT, MMIS and BMD, and concentrate its attention and resources on making the benefits of space available to the soldier in the field.
>
> 2. The progression defined by the Army Space Concept to acquire terminals and processors and develop space systems which will make space technology more accessible to the Army operational and tactical level commander must be maintained. The Army Demo Program should continue to develop tactical interest in space technology.
>
> 3. 'Sensor Fusion' must be encouraged to provide the battlefield commander with all the data collected by space systems which he requires. 'Sigma Star' must be fielded in its entirety.

4. The Army TENCAP should be expanded to make information collected by RSTA systems more accessible to operational and tactical users. Steps should also be taken to ease the classification problems of RSTA products provided by national systems which have plagued rapid dissemination of those products to the operational commander in the past.

5. The ability to launch communications and reconnaissance LIGHTSATs in support of forces in the theater, to supplement or replace inadequate or inoperable space systems, must be provided to the operational commander. An operational headquarters should be provided to the supported CINC from SPACECOM to do this, much as Special Operations Command provides a headquarters to direct special operations forces in the theater.

6. The Army's space organization must be revamped, to place all Army space activities under one roof and point them toward one goal, so that its space focus is not lost. The most likely candidate for such a job is the SDC Commander, who has the technical expertise necessary to keep the focus of the space program on the soldier in the field.

7. The Army's officer corps must receive an increased level of education about Army space operations, beginning at the lowest levels and continuing throughout their careers, to make them aware of the potential benefits which space technology can provide them as AirLand Battle commanders.

The underlying thought behind each of these recommendations is that they all revolve around the first. Everything done by the Army in space must ultimately come back to the idea that the Army is a user of space services, and that the way these services are used must enhance the battlefield capabilities of the operational and tactical level commanders. Every effort must be made to make the national space systems easily and readily accessible to these commanders, without the distraction caused by the requirement to actually operate one of the national strategic systems. These efforts must be directed by a single office which will ensure that the Army's space operations remain focused on the operational and tactical, and are not misled by the strategic. If implemented with this thought in mind, these recommendations will make the integration of space technology and AirLand Battle doctrine a reality in the near future.

The Army's Role in Space

This thesis has been an attempt to demonstrate that the space technology which now provides our world with so many almost indispensable capabilities has as many potential applications for the Army as well. Indeed, the warfighting doctrine of the Army, AirLand Battle and AirLand Battle Future, is already somewhat dependent on space technology for its successful execution, and will become increasingly dependent on it as the years go by. To its credit, the leadership of the Army has recognized both the potential and the dependence, and has developed a Space Concept which, in theory, institutes systems and organizations to oversee the effective integration of the two. However, the implementation of that concept is currently not sufficiently focused. The Army vacillates between visions of itself as an operator in the space arena versus a user of space services. It has not yet determined if its policy should be 'The Army in Space' or 'Space in the Army.'

In Chapter 1, Colonel Jan V. Harvey was quoted in Military Review bemoaning the fact that the Army was no longer the lead service in space operations, as it had been in the late 1950's, but was now only a lowly customer of the services provided by space systems.[3] Consequently, he concluded that its ability to use space for its benefit was severely curtailed. The crux of the matter, however, is that by trying to operate in space as it had when it was the lead service, the Army was failing to influence the development of systems which it could use to enhance its battlefield operations in the future. It forgot that a customer exerts considerable influence in this world, as long as he makes his desires known.

To fully realize the potential benefits which space technology can provide, and to effectively and fully integrate them into its warfighting doctrines, the Army must completely and unreservedly accept the fact that it is indeed a customer of the services provided by space systems, and no longer seek to be an operator of those systems. It must focus on putting 'Space in the Army,' not the 'Army in Space.'

The distinction, and its acceptance, is essential.

NOTES

[1]From a reprint of an article by Steve Malutich and Bruce Thieman, "Space Systems for Military Use," from Space: The Fourth Military Arena (Maxwell AFB, AL: Air Command and Staff College, March 1990), found in Space Operations, the A552 Course Syllabus from the U.S. Army Command and General Staff College, (Ft Leavenworth KS: USA Command and General Staff College, 1 November 1990), 113, 114.

[2]U.S. Department of the Army, FM 100-18: Space Operations, (Washington DC: Department of the Army, August 1990), 37.

[3]Ibid., 23.

[4]Robert H. Williams, "Iridium Offers Contact to any Point on Earth," Signal 45 (February 1991): 95, 96.

[5]For a brief description of 'Sigma Star' refer to the following articles in Signal: by Colonel Lawrence J. Dacunto, "Army Command & Control Initiatives" in the November 1988 issue; and by Lieutenant Colonel David R. Gust, "Army Battlefield C^3I Using Satellited Communications" in the May 1989 issue.

[6]Malutich, 113.

[7]Nicholas L. Johnson, Soviet Military Strategy in Space (New York: Jane's Publishing Inc., 1987), 58.

[8]Jan V. Harvey and Alwyn H. King, "Space: The Army's New High Ground," Military Review 65 (July 1985): 39.

APPENDIX A

LIST OF ACRONYMS

LIST OF ACRONYMS

ABM	Anti-Ballistic Missile
ACSC4	Assistant Chief of Staff for Command, Control, Communications & Computers
ACTS	Advanced Communications Technology Satellite
AFATDS	Advanced Field Artillery Tactical Data System
AFSAT	Air Force Satellite Communications system
AFSPACECOM	Air Force Space Command
AISI	Automated Integrated Survey Instrument
ALB	AirLand Battle
ALB-F	AirLand Battle Future
ALDP	Advanced Launch Development Program
ALS	Advanced Launch System
AMC	Army Materiel Command
AMSSA	Assured Missions Support Space Architecture
APT	Automatic Picture Transmission terminal
ARSPACE	Army Space Command
ARSTAFF	Army Staff
ASARDA	Assistant Secretary of the Army for Research, Development & Acquisition
ASAS	All Source Analysis System
ASAT	Anti-Satellite
ASI	Army Space Institute
ASMP	Army Space Master Plan
ASPO	Army Space Program Office
ASTRO	Army Space Technical Research Office

ATACMS	Army Tactical Missile System
ATBMP	Army Technology Base Master Plan
ATCCS	Army Tactical Command and Control System
BAI	Battlefield Air Interdiction
BFA	Battlefield Functional Area
BM/C3	Battle Management/Command, Control & Communications
BMD	Ballistic Missile Defense
BSTS	Boost Surveillance & Tracking System
C^2	Command and Control
C^3I	Command, Control, Communications & Intelligence
CAC	Combined Arms Command
CAMMS	Combined Arms Mobility Modeling System
CAS	Close Air Support
CECOM	Communications-Electronics Command
CINC	Commander-in-Chief (of a combatant command)
CNES	Centre Nationale d'Etudes Spatiales
COE	Corps of Engineers
COSCOM	Corps Support Command
CSA	Chief of Staff of the Army
CSOC	Consolidated Space Operations Center
CSS	Combat Service Support
CSSCS	Combat Service Support Control System
DARPA	Defense Advanced Research Projects Agency
DCSINT	Deputy Chief of Staff for Intelligence
DCSOPS	Deputy Chief of Staff for Operations
DE	Directed Energy

DMSP	Defense Meteorological Satellite Program
DOC	Department of Commerce
DOD	Department of Defense
DOT	Department of Transportation
DSCS	Defense Satellite Communications System
DSP	Defense Support Program
DTSS	Digital Topographic Support System
EHF	Extremely High Frequency
ELINT	Electronic Intelligence
EMP	Electromagnetic Pulse
EORSAT	ELINT Ocean Reconnaissance Satellite
EOSAT	Earth Observation Satellite company
EPDS	Electronic Processing and Dissemination System
EPLRS	Enhanced Position Location & Reporting System
ERINT	Extended Range Intercept Technology
ERIS	Exoatmospheric Re-Entry Vehicle Interceptor
ESA	European Space Agency
ETL	Engineer Topographic Laboratory
ETUT	Enhanced Tactical User's Terminal
FAAD C2	Forward Area Air Defense Command & Control system
FLTSATCOM	Fleet Satellite Communications system
FSB	Forward Support Battalion
FY	Fiscal Year
GBR	Ground-Based Radar
GEO	Geosynchronous Earth Orbit
GLONASS	Global Navigation Satellite System

GMFSC	Ground Mobile Forces Satellite Communications
GNP	Gross National Product
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
GSTS	Ground-Based Surveillance & Tracking System
HEDI	High Endoatmospheric Defense Interceptor
HVG	Hypervelocity Gun
IMETS	Integrated Meteorological System
INTELSAT	International Telecommunications Satellite organization
IONDS	Integrated Operational Nuclear Detonation Detection System
IPB	Intelligence Preparation of the Battlefield
IPDS	Imagery Processing and Dissemination System
ISN	Integrated Survivable Network (Communications)
JCS	Joint Chiefs of Staff
JSTARS	Joint Surveillance Target Attack Radar System
JTIDS	Joint Tactical Information Distribution System
KE	Kinetic Energy
LABCOM	Laboratory Command
LEAP	Lightweight Exoatmospheric Advanced Projectile
LEASAT	Leased Satellite
LEO	Low Earth Orbit
LIGHTSAT	Lightweight Satellite
LPS	Limited Protection System
MACOM	Major Command
MAD	Mutually Assured Destruction

MCIS	Multichannel Initial System
MCOS	Multichannel Objective System
MCS	Maneuver Control System
MILSATCOM	Military Satellite Communications
MILSTAR	Military Strategic Tactical & Relay (satellite)
MLRS	Multiple Launch Rocket System
MMIS	Military Man in Space
MMT	MILSTAR Manpack Terminal
MSE	Mobile Subscriber Equipment
MSI	Multi-Spectral Imagery
NASA	National Aeronautics & Space Administration
NASP	National Aerospace Plane
NAVSPACECOM	Naval Space Command
NAVSTAR	Navigation System Timing and Ranging
NCA	National Command Authority
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
NPB	Neutral Particle Beam
NUDETS	Nuclear Detection System
PALS	Protection Against Accidental Launch System
PBW	Particle Beam Weapon
PLGR	Precision Lightweight GPS Receiver
PROFILE	Passive Radio Frequency Interference Location Experiment
R&D	Research & Development
RDTE	Research, Development, Test & Evaluation
RORSAT	Radar Ocean Reconnaissance Satellite

RSSC	Regional Space Support Center
RSTA	Reconnaissance, Surveillance & Target Acquisition
SA	Secretary of the Army
SAC	Strategic Air Command
SAR	Synthetic Aperture Radar
SBI	Space-Based Interceptor
SCAMP	Single Channel Man Portable terminal
SCOTT	Single-Channel Objective Tactical Terminal
SDC	Strategic Defense Command
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization
SDS	Space Defense System; also Satellite Data System
SHF	Super High Frequency
SINCGARS	Single Channel Ground & Airborne Radio System
SLAM	Standoff Land Attack Missile
SLGR	Small Lightweight GPS Receiver
SOF	Special Operations Forces
SPOT	Satellite Pour l'Observation de la Terre
SSLV	Standard Small Launch Vehicle
SSTS	Space-Based Surveillance & Tracking System
STS	Space Transportation System
STT	Small Tactical Terminal
SW	Special Weapons
TACSAT	Tactical Satellite
TDRSS	Tracking & Data Relay Satellite System
TENCAP	Tactical Exploitation of National Capabilities

THMT	Tactical High Mobility Terminal
TIROS	Television and Infrared Observation Satellite
TMD	Theater Missile Defense
TPIO-SPACE	TRADOC Program Integration Office for Space
TRADOC	Training & Doctrine Command
UFO	UHF Follow-On
UHF	Ultrahigh Frequency
USAISC	United States Army Information Systems Command
USAREUR	United States Army Europe
USSPACECOM	United States Space Command
WEFAX	Weather Facsimile terminal
WWMCCS	World Wide Military Command & Control System

APPENDIX B

DEFINITIONS

DEFINITIONS

- AirLand Battle: the Army's basic warfighting doctrine. It reflects the structure of modern warfare, the dynamics of combat power, and the application of the classic principles of war to contemporary battlefield requirements, and recognizes the inherently three-dimensional nature of modern warfare.

- Antisatellite System: a system used to attack a satellite with the intention of disrupting, degrading, or destroying its operation. It can be either ground or space based, and may use kinetic, electronic, or directed energy.

- Ballistic Missile Defense: the application of capabilities resulting in the negation of effects of attacking missiles. A ballistic missile is one which does not rely on aerodynamic surfaces to produce lift.

- Battlefield Operating System: a concept identifying the broad area of assets or tools available to the AirLand Battle commander, widely used in the task organizing process. The seven Battlefield Operating Systems are: Maneuver; Fires; Air Defense; Intelligence; Mobility, Countermobility & Survivability; Combat Service Support; and Command & Control.

- Civil Space Sector: those governmental space activities intended to significantly enhance the nation's science, technology, economy, pride, sense of well-being, and world prestige. They comprise a balanced strategy of research, development, operations, and technology for science, exploration, and appropriate applications.

- Commercial Space Sector: those non-governmental space activities which are the result of private-sector investment. Ideally, they are market driven and generate economic benefits for the nation.

- Force Application Operations: combat operations conducted from space with the objective of strategic defense and power projection.

- Force Enhancement Operations: those space related support operations conducted to improve the effectiveness of both terrestrial and space-based forces.

- Imagery: collectively, the representations of objects reproduced electronically or by optical means on film, electronic display devices, or other media.

- National Security Space Sector: those governmental space activities which are necessary to national defense.

- National Space Policy: national commitment to the exploration and use of space in support of the well being of the Nation.

- the Nation's Space Program: all of the United States' efforts in space, to include those of NASA, DOD, and commercial ventures. Typically, this is broken into three space sectors as outlined in the National Space Policy of 1988: civil, commercial, and national security.

- Operational Art: the employment of military forces to attain strategic goals in a theater of war or theater of operations through the design, organization, and conduct of campaigns and major operations. It involves fundamental decisions about when and where to fight and whether to accept or decline battle.

- Reconnaissance: a mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy; or a mission undertaken to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area.

- Space: the medium above the earth's atmosphere, distinct from the earth's atmosphere. Administratively, space begins at an altitude of 44 nautical miles above the earth's surface.

- Space Control: the ability to ensure one's own freedom of action in space, and the ability to deny such freedom of action to an adversary. Space control operations involve anti-satellite, survivability, and surveillance capabilities.

- Space Defense: all defensive measures designed to destroy attacking enemy vehicles, including missiles, while in space, or to nullify or reduce the effectiveness of such an attack.

- Space Forces: the personnel, systems, and organizational structure required to conduct military space operations.

- Space Operations: the employment of tactics, techniques and procedures in space, or related to space, to achieve benefit from space systems.

- Space Power: the ability of a nation to exploit the space environment in pursuit of national goals and purposes. It involves utilization of all elements of the nation's space infrastructure.

- Space Support: those things required to ensure that space control and support of terrestrial forces is maintained. It includes such activities as launching and deploying space vehicles, maintaining and sustaining space vehicles while on orbit, and recovering space vehicles if required.

- Space System: a system designed for the express purpose of operating in the medium of space. Typically, a space system is composed of three segments: a ground segment; the spacecraft itself; and the communications control segment which provides the link between the spacecraft and the using or controlling ground station.

- Strategic Intelligence: intelligence that is required for the formation of policy and military plans at national and international levels.

- Strategy: in this thesis, strictly Military Strategy. It is the art and science of employing the armed forces of a nation or alliance to secure policy objectives by the application or threat of force. It sets the fundamental conditions of operations in war, establishes goals in theaters of war and theaters of operations, and assigns forces, provides assets, and imposes condictions on the use of force.

- Tactical Intelligence: intelligence which is required for the planning and conduct of tactical operations.

- Tactics: the art by which corps and smaller unit commanders translate potential combat power into victorious battles and engagements. Sound tactics win battles and engagements by moving forces on the battlefield to gain positional advantage over the enemy; by applying fire support to facilitate and exploit that advantage; and by assuring the sustainment of friendly forces before, during, and after engagement with the enemy.

APPENDIX C

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